Research Memorandum 76-9

JOB OBJECTIVES FOR M60A1AOS TANK GUNNERY

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UNIT TRAINING AND EVALUATION SYSTEMS TECHNICAL AREA

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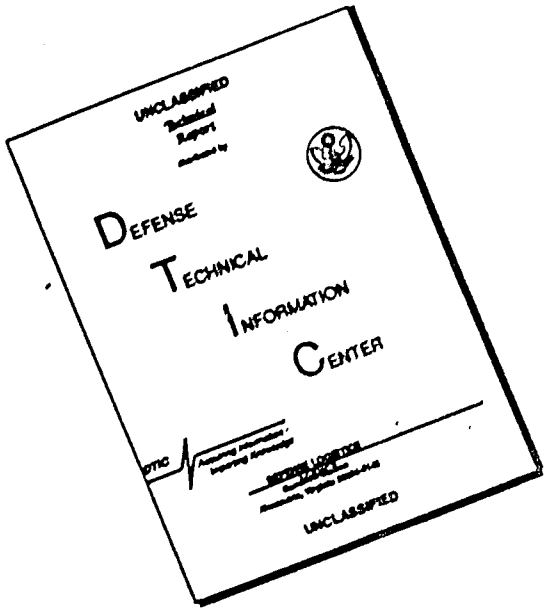

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This project was designed, implemented, and directed by Ronald E. Kraemer. It was conducted at HumRRO's Central Division, Louisville, Kentucky, where William C. Osborn is the Director.

We are grateful for the assistance provided in specifying standards for the job objectives by E7 Jerry L. Cook, U.S. Army Research Institute; E6 James A. Smith, Gunnery Department, US Army Armor School; and E6 Terrance Terman, US Army Armor School Brigade.

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SUMMARY

Recognizing a possible need for increased efficiency in gunnery training, and the dependence of increased training efficiency on the availability of a pool or data base of gunnery job objectives, the US Army Armor School initiated research to develop the data base and to examine proposed gunnery training. A contract was awarded by the US Army Research Institute for the Behavioral and Social Sciences (ARI) to the Human Resources Research Organization (HumRRO) for a project to:

1) Develop a performance-requirements data base, or pool of job objectives for M60A1AOS tank gunnery.

2) Specify the tank gunnery training objectives that are implied in TC 17-12-5 (Tank Gunnery Training; October 1974).

3) Compare the gunnery training objectives and the gunnery job objectives.

These three objectives were accomplished, and the following conclusions reached:

1) The gunnery job objectives developed during this project seem comprehensive. They describe the full range of ways that targets can be neutralized using M60A1AOS guns. If the job objectives are comprehensive, then a basis has been provided for:

   A. Comparing the content of proposed gunnery training to gunnery job content.

   B. Developing training for crews of tanks other than the M60A1AOS.

   C. Increasing the efficiency of gunnery training.

   D. Evaluating the effectiveness of gunnery training.

2. The gunnery performance standards proposed in TC 17-12-5 (October 1974) should be revised for increased specificity and decreased reliance on expert opinion. Some flexibility in setting gunnery performance standards may be desirable, but the need for flexibility must be weighed against the need for knowing "where we are" with respect to gunnery readiness. The basis for establishing gunnery standards also needs to be examined. Standards should not be set on the basis of the normative performance of our own gunners, or on the basis of expert opinion. They should be set on the basis of the best available information on enemy capability.

3. The relevance of the gunnery exercises proposed in TC 17-12-5 (October 1974) to the gunnery job seems unquestionable. Nearly all of the exercises were related to at least one job objective.

4. Gunnery training, as proposed in TC 17-12-5 (October 1974) is not comprehensive. Some parts of the gunnery job receive extensive coverage in the new tables. Other parts are not treated at all. Policy makers who are responsible for decisions about gunnery training content should carefully review what is being left out of proposed training as compared to what is being included. The results in this report make such a review possible.

5. The efficiency of the gunnery training proposed in TC 17-12-5 (October 1974) can be increased by teaching more within existing resource constraints, or by maintaining present proficiency levels at less cost. Identifying gunnery skills that cut across job objectives, and including these component skills in training should promote learning of the maximum number of job objectives with no increase in training cost. Ongoing research to determine the least expensive mix of live fire and simulation that will produce desired or present proficiency levels should be continued.

6. Gunnery training is one of several means of accomplishing the objectives of gunnery. Potentially less expensive means, such as improved equipment reliability and personnel selection, should be considered.

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(6) JOB OBJECTIVES FOR M60A1AOS TANK GUNNERY

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JOB OBJECTIVES FOR M60A1AOS TANK GUNNERY

Developing and implementing effective training would be easy if time and funds were unlimited. But training resources always are limited. And because resources are limited, the effectiveness of a training program is no longer a sufficient measure of its adequacy. Increasingly the requirement is for programs that are efficient -- programs that get the job done at least cost.

Inefficiency in training usually comes in two varieties. The first is overtraining: teaching trainees more than they need to know and do in order to perform their jobs effectively. The second variety is undertraining. Related to both of these sources of inefficiency is a third (and most egregious) characteristic of training: "teaching the wrong thing"; that is, teaching skills and knowledge that are either irrelevant or detrimental to effective job performance.

The way to increase training efficiency is to teach only those skills and knowledge that are necessary for trainees to perform their jobs effectively. A very important consideration is implied here; namely, that prior to developing and implementing a training program, training developers must know, and be able to specify exactly, the behavior involved in effective job performance. This observation certainly is not startling. Neither is it trivial. Training developers who do not know and cannot specify exactly the behavior required for effective job performance are forced to guess. And if their guesses are wrong, nothing about their training programs can be right.

Specifying job-effective behavior is difficult, time-consuming, and expensive. One is not surprised, therefore, to find that inadequate programs are tolerated on the grounds that effective ones would cost too much. This line of reasoning is deceptively attractive because of difficulties involved in comparing training programs. The costs of developing and implementing a new program can be measured easily, but difficulties always are encountered in measuring the costs of an existing, perhaps ineffective program -- hidden costs, such as equipment damage attributable to misuse, personal injury, or for that matter, death in combat. Occasions do arise, however, in which the costs of inadequate training become so apparent as to obviate the need for precise measurement. Such situations involve:

1. Training large numbers of personnel to perform as parts of a larger working unit with a common mission or goal.

2. Dramatic, publicly observable evidence of failure to accomplish the mission or achieve the goal.

One example of a situation that fits this description is the training of military personnel in times of national emergency. Because of the necessity for training large numbers of personnel under severe time constraints during World War II, and because the effects of inadequate training were dramatic and easily observed, the need for increased training efficiency was recognized. The training development methods used then, and modified during the past 30 years, have found increasing acceptance in military and industrial settings. Fundamental to all such methods is the concept of task analysis, a procedure which yields

descriptions of behavior at successively greater levels of detail, beginning with a simple enumeration of task "areas" and ending with exhaustive descriptions of behavior in terms of "task elements."

Another method for generating descriptions of job-relevant behavior is the Critical Incident Technique (Flanagan, 1954), in which records of extremely effective and extremely ineffective job-related behavior are generated on the basis of interviews with incumbents, supervisors, peers of incumbents, or any other group whose judgments of "effective" and "ineffective" are credible.

Finally, there is the method (not yet named, to the best of our knowledge) that was used in this project. After deciding on an overall statement of the job "task" or objective ("neutralize targets"), all conditions that are likely to affect task performance are identified. (Target characteristics, weapons, and fire delivery methods are examples of conditions that affect gunnery performance.) All possible combinations of the conditions are then examined, in order to identify all possible ways that the job "task" can be performed.

The goal of all of the methods cited above is to form a comprehensive data base of job-relevant behavior. The behavior comprising the data base can be thought of as a <u>pool</u> of all possible job objectives, from which objectives for training or items for testing can be derived. Without a pool against which to compare training or test content, it is impossible to determine what has been left out of training or testing. Another way of viewing the concept is that selecting the content of training programs and testing programs requires <u>sampling</u>

the behaviors encompassed by the job. The pool or data base generated by task analysis, critical incidents, or the method used in this project defines the population or domain of job behavior from which samples of behavior are taken for inclusion in training, evaluation, or both. Without the pool or data base, we have no way of knowing which "chunks" of the job are not being addressed in training or testing. And without knowing what has been left out, we have no basis (other than opinion) for judging the adequacy of training or test content.

Rationale

Recognizing a possible need for increased efficiency in tank gunnery training, and the dependence of increased training efficiency on the availability of a pool or data base of gunnery job objectives, the US Army Research Institute for the Behavioral and Social Sciences (ARI) initiated research to develop the data base and to examine proposed gunnery training. A contract for assistance in achieving these objectives was awarded by ARI to the Human Resources Research Organization (HumRRO).

Purpose

The purposes of this project were to:

1. Develop a performance-requirements data base, or pool of job objectives for M60A1AOS[1] tank gunnery.
2. Specify the tank gunnery training objectives that are implied in TC 17-12-5 (Tank Gunnery Training; October 1974).
3. Compare the gunnery training objectives and the gunnery job objectives.

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[1]The M60A1AOS is the preliminary version of the M60A1E3, and includes only the add-on stabilizer portion of the E3 package.

JOB OBJECTIVES AND TRAINING OBJECTIVES: GENERAL CONSIDERATIONS

Since there are no universally accepted definitions of "job objective" and "training objective," we will define the terms as used in this report. Both terms are subsumed under the rubric, "human performance objectives," which are characterized by three parts:

1. Activity or task statement.
2. Conditions statement.
3. Standards statement.

Activities or Tasks

Activities or tasks are brief statements, usually consisting of an active verb and a direct object, of the behavior addressed by the objective. "Neutralize targets" is a task or activity statement for tank gunnery.

Conditions

Conditions refer to any circumstances that might be expected to alter the quality or the productivity of the task or activity that is to be performed. Day and night, stationary and moving firing vehicles and targets, and weapons used, all are "conditions" for the tank gunnery activity, "neutralize targets."

Standards

Standards, as used in human performance objectives, describe the quality or the amount (quantity, production) of the performance of interest, or both. Performance quality in gunnery is expressed as

accuracy, and production as number of hits. As in all standards, quantity and quality measures of human performance have little utility alone. To be useful, the quantity and quality measures must be expressed relative to cost: how much are we willing to pay to obtain the desired quality or quantity of performance? In human performance objectives indirect measures of cost usually are used. Time and amount of material expended are examples of human performance "costs."

A standard for tank gunnery might be, "score a second-round hit within seven seconds." In this standard the measure of:

1. Quality is "hit" (as opposed to "miss").
2. Quantity is <u>one</u> hit -- the measure of production implied in the standard.
3. Cost is seven seconds and two rounds.

Human performance standards frequently are stated imprecisely. One often finds, for example, standards stated as, "90 percent hit rate," or "five rounds per minute." Standards should include separate measures of quality, quantity and cost, for several reasons:

1. Clarity of communication to test designers, test administrators, and others. "Ninety percent hit rate," and "five rounds per minute" are incomplete standards, in that they have no cost measures associated with them. "Ninety percent hit rate" does not communicate the number of rounds to be expended. And "five rounds per minute" does not communicate the total amount of time that will be allowed for achieving the five-per-minute criterion.
2. The possibilities for statistical inference with respect to performance reliability and confidence levels are quite different for, say, 9 out of 10 hits as opposed to 90 out of 100 hits.
3. To permit various combinations of basic data for analyses of standards by interested investigators.

Job, as Opposed to Training Objectives

The foregoing discussion pertains to human performance objectives, the term that subsumes both job objectives and training objectives. The distinction between job objectives and training objectives remains to be made.

Job objectives describe performance, in terms of activities, conditions, and standards, that will be demonstrated as part of effective performance on the job. Thus, for the tank gunner "job," a job objective might be:

> "Given (a) a stationary M60A1AOS tank with the main gun battlesighted with SABOT, (b) an operational gunnar's day periscope, and (c) a moving tank target that is visible at less than 3200 meters without artificial light during the day; the gunner will open fire within 16 seconds, and neutralize the target within 24 seconds of the alert element of the tank commander's command, using no more than two rounds."

Training objectives describe performance, in terms of activities, conditions, and standards, that is to be demonstrated in training. A training objective for tank gunnery might be:

> "Given (a) a stationary firing vehicle that is equipped with a main gun simulation device, (b) an operational gunner's telescope, and (c) a moving silhouette target (flank view of Soviet tank) that is visible at 1600 meters with white light; the gunner will open fire within 10 seconds, and neutralize the target within 15 seconds of the alert element of the tank commander's command, using no more than two (simulated) rounds."

Job objectives and training objectives sometimes are identical. The gunnery job objective cited above could also be a training objective. But not all job objectives are training objectives. This is

so because there usually are some skills and knowledge that are required for effective job performance, but are not included in training for the job. Certain skills and knowledge may be excluded from training for any of several reasons:

1. Ease of learning on the job.
2. Infrequency of occurrence on the job.
3. "Non-criticality" to effective job performance.
4. High cost.

Job objectives pertaining to neutralizing aircraft targets with the caliber .50 machinegun are examples of job objectives that are not training objectives.

Finally, not all training objectives are job objectives. Some training objectives, for example, are enabling objectives. Their mastery is required for mastery of other training objectives, but they never are practiced on the job. Objectives that require using a burst-on-target simulator are examples of training objectives that are not job objectives.

JOB OBJECTIVES

Job objectives for tank gunnery were specified for use in subsequent compariaons with the training objectives implied in the new gunnery tables (TC 17-12-5), and for potential use as a file or data base for deriving training objectives and evaluating training effectiveness.

Method

The method for developing job objectives began by specifying the overall task or activity involved in tank gunnery; namely, neutralizing targets, using available weaponry. Attention was then directed to:

1. Selecting conditions for use in the objectives. What conditions could affect, for better or worse, a tank crew's ability to neutralize targets?

2. Selecting levels within conditions for use in the objectives. Given that a condition such as target range is likely to affect a crew's ability to neutralize targets, what orders of magnitude or "levels" of target range should be included in the objectives?

3. Combining levels across conditions to form a comprehensive set of objectives. The number of possible job objectives for any one task or activity is a function of the number of conditions and levels within conditions associated with the objective. If one task has two conditions (target range and visibility, for example) and two levels within each condition (<1100 meters and >1100 meters; visible and not visible) then the number of possible combinations of levels across conditions, and the number of possible objectives, is 2x2=4:

A. Visible at <1100 meters.

B. Visible at >1100 meters.

C. Not visible at <1100 meters.

D. Not visible at >1100 meters.

4. Specifying performance standards for each combination of levels across conditions. Gunnery performance standards might be expected to differ depending on, for example, whether the target was visible at <1100 meters, or not visible at >1100 meters.

Selecting Conditions

Having agreed that the overall task or activity for tank gunnery was to neutralize targets, we then asked what combinations of weapons, fire-delivery methods, crew members, and fire control instruments could be used by crews to neutralize targets. The results of this inquiry are summarized in Figure 1.

The lines connecting the rectangles in Figure 1 indicate "allowable" relationships among levels of the conditions. Using either the battlesight (BS) or precision (PRE) method of fire delivery with the main gun, for example, the tank commander can neutralize targets using the rangefinder (RFDR) with either IR or daylight (D) accessories. The tank commander cannot, according to Figure 1, use the gunner's periscope (PER) or telescope (TEL).

As can be inferred from Figure 1, we had at this point in the project identified four conditions that could affect gunnery performance, and a total of 18 levels within the four conditions. The conditions and levels were:

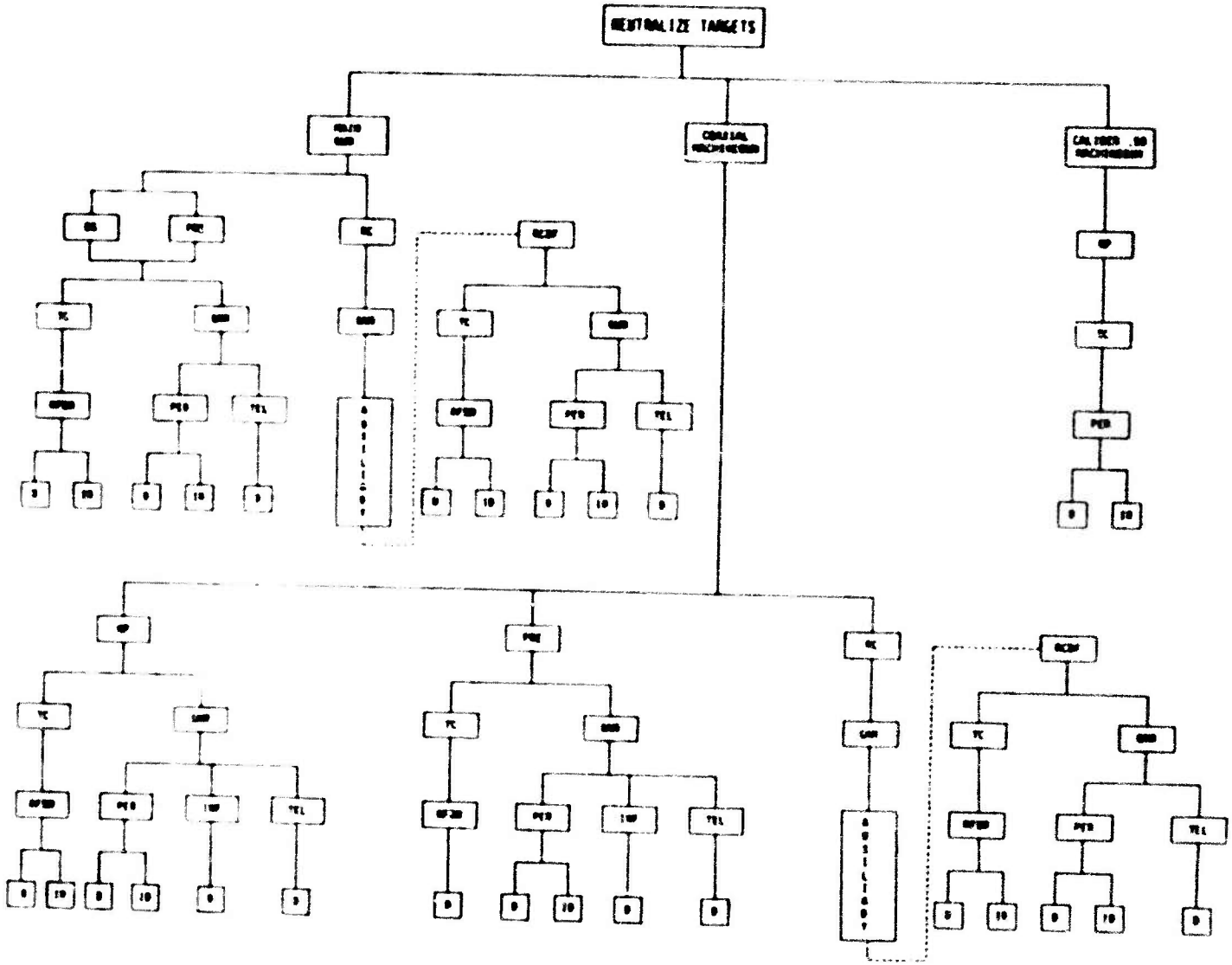


FIG. 1. Combinations of weapons, fire-delivery methods, crew members, and fire-control instruments available for neutralizing targets by M60A1AOS crews.

1. Weapon:
   - Main Gun.
   - Coaxial Machinegun.
   - Caliber .50 Machinegun.

2. Fire-Delivery Method:
   - Battlesight (for main gun; "non-precision" or NP for the machineguns).
   - Precision (PRE).
   - Range Card (RC).
   - Range Card Lay to Direct Fire (RCDF).

3. Crew Member:
   - Tank Commander (TC).
   - Tank Gunner (GNR).

4. Fire Control Instrument:

RFDR, Day:	Rangefinder.
RFDR, IR:	Rangefinder with metascope.
TC/PER, Day:	Tank commander's cupola periscope.
TC/PER, IR:	Tank commander's infrared periscope.
GNR/PER, Day:	Gunner's periscope.
GNR/PER, IR:	Gunner's infrared periscope.
TEL:	Gunner's telescope.
INF:	Gunner's infinity sight.
AUX:	Auxiliary fire controls (azimuth indicator and elevation quadrant).

The next step in selecting conditions for use in the job objectives was to ask, "What conditions other than those shown in Figure 1, might be expected to affect -- for better or worse -- a qualified crew's ability to neutralize targets?" This question was answered by three members of the project staff who formerly were tank commanders, on the basis of their own combat experience, and a review of technical documentation. Their answers were presented in the form of lists of conditions, which in their view, might affect a tank crew's effectiveness in neutralizing targets. Sample entries on the lists were flat as opposed to rough terrain, clear as opposed to cloudy skies, and vehicle as opposed to troop targets. The project director sorted the

entries in the lists in an effort to discover superordinate classes of conditions under which each of the individual entries could be classified.

An initial result of this exercise was the realization that targets, like all visual stimuli, could be classified in terms of:

1. Contrast, as measured in foot-lambents of target brightness over foot-candles of background illumination.

2. Apparent size, which is measured in degrees of visual angle subtended by the target; and is a function of range and actual size of the target.

3. Apparent speed, which is measured in degrees of visual angle subtense per second; and is a function of range, speed, and direction of motion.

The use of contrast, apparent size, and apparent speed to describe targets was immediately abandoned for several reasons. The main reason was that none of the three measures provides basic data on target type (troops, tanks, for example) or target range -- data that are essential for bringing effective fire to bear on targets.

The major classes of conditions that emerged as the result of the exercise described above were:

1. Firing Vehicle Motion.

2. Target Motion.

3. Target Type (e.g., tank as opposed to troop).

4. Target Visibility.

5. Target Range.

6. Ammunition.

7. Day, as opposed to Night firing.

Selecting Levels Within Conditions

Applying the methods described above yielded a set of 11 classes of conditions or variables that could affect a crew's capability to neutralize targets.

1. Weapon.
2. Fire-Delivery Method.
3. Crew Member.
4. Fire Control Instrument.
5. Firing Vehicle Motion.
6. Target Motion.
7. Target Type.
8. Target Visibility.
9. Target Range.
10. Ammunition.
11. Day/Night.

To appreciate how levels were selected for each of these conditions, it helps to understand the difference between continuous and discrete variables.

Continuous variables are characterized by interval scales, and by being infinitely subdivisible. An interval scale is one in which 2 is twice as much as 1, 4 is twice as much as 2, and so forth. Scales used to measure the range variable (or condition) are interval scales, since 50 meters are twice 25 meters, 100 is twice 50, etc. The range variable also is infinitely subdivisible: 10 meters is halfway between 0 and 20 meters, 5 is halfway between 0 and 10, ad infinitum.

Because range is an interval scale, and because the scale is infinitely subdivisible, range is a continuous variable (or condition).

In contrast with continuous variables are discrete variables -- variables such as type of ammunition and type of target. There are only so many members in the ammunition "class," and there are no values of the variable between members of the class: there is no "value" of ammunition between SABOT and HEAT, or between HEAT and Caliber .50. Similarly, there are no "values" of tank targets between tank and troops, or between troops and bunkers. Members of classes of variables such as ammunition and target type are, therefore, discrete. Kinds or types of anything are discrete. Inches, pounds, and cubic centimeters are continuous.

Specifying levels for the discrete conditions selected for inclusion in the job objectives was no problem. For conditions such as target type, fire-delivery method, and ammunition, we simply had to describe what existed in the real world: the numbers of target types, fire-delivery methods, and kinds of ammunition are finite, small, and easily identifiable.

Selecting levels for the continuous conditions was a different matter. At one extreme, one could say that tank crews will be able to neutralize targets at any range, traveling at any speed, under any conditions of visibility. And, in fact, this is what the gunnery "job" really is about. But we wanted to relate conditions such as target range, speed, and visibility to performance standards. Job objectives that required neutralizing any target at any speed under any conditions

of visibility were, therefore, judged unsatisfactory (though perfectly realistic): small targets moving quickly as night are more difficult to neutralize than are large stationary targets in broad daylight. And such differences should be reflected in performance standards if the standards are to be useful.

At the other extreme, one might write separate gunnery job objectives for targets moving at 8 MPH, 8.1 MPH, 8.2 MPH; or for targets at 1000 meters, 1001 meters, 1002 meters, etc. Such a procedure would have yielded considerably more than the number of gunnery objectives necessary to describe how targets could be neutralized. Compromises were necessary, therefore, in selecting levels of the continuous conditions -- compromises that would avoid proliferation of objectives on the one hand, and inability to relate performance standards to conditions on the other. The kinds of compromises made, and the bases for making them are noted in the following sections, which describe how levels were selected within each of the 11 conditions.

Weapon. The weapon condition is a discrete variable. As noted earlier, there are no "values of weapon" between the main gun and coaxial machinegun, or between main gun and caliber .50 machinegun, or between the coax and caliber .50. Selection of levels of weapons was dictated by what exists (as was selection of levels for all other discrete variables). The levels of the weapon condition are: main gun, coaxial machinegun, and caliber .50 machinegun.

Fire-Delivery Method. Fire-delivery method is another discrete condition, with levels defined by what exists in the real world. Four

levels of fire-delivery method were identified: precision, range card, range card lay to direct fire, and battlesight (or "non-precision" for the machineguns).

Crew Member. This is another discrete variable in that M60A1AOS tank crews consist of only four positions: tank commander, gunner, loader, and driver. Two levels of the crew member variable were identified, corresponding to the two members of the crew who normally fire the weapons: tank commander and gunner.

Fire Control Instrument. Nine levels of this discrete condition were identified (see Figure 1): TC's rangefinder, TC's rangefinder with metascope, TC's cupola periscope, TC's IR periscope, GNR's periscope, GNR's IR periscope, GNR's telescope, GNR's infinity sight, and auxiliary fire controls.

Firing Vehicle Motion. Vehicle motion is a continuous variable, in that the M60A1AOS can travel at any speed from slightly more than 0 MPH to about 30 MPH. The problem of selecting levels of vehicle motion disappeared in light of two practical considerations:

1. Our desire to keep the number of job objectives minimal (recall that the number of objectives increases in direct proportion to the number of conditions in the objectives, and the number of levels within conditions).

2. The traditional method of stating tank motion in gunnery training.

Based on these practical considerations, two levels of firing vehicle motion were selected: stationary and moving.

For purposes of this project all moving firing vehicles were assumed to be traveling at rates of 10 to 15 MPH.

Target Motion. The levels of target motion selected for use in the job objectives were identical to those selected for firing vehicle motion: stationary and moving. The reasons underlying the selection of levels also were identical to the reasons for selecting the levels of firing vehicle motion: desire to minimize the number of objectives, and conformance to existing practice.

For purposes of this project all moving targets were assumed to be traveling at rates of 8 to 15 MPH.

Target Type. Our initial list of levels for the target type variable consisted of six entries:

1. Tank or tank-like.
2. Bunker or pillbox.
3. Light-armored or unarmored vehicle.
4. Crew-served weapon.
5. Troops.
6. Aircraft.

As will be seen later, it proved possible to combine two levels of target type in some of the objectives: tank and light-armored vehicle, for example, for some main gun battlesight engagements; and bunkers and crew-served weapons vehicles for others.

Target Visibility. Target visibility can vary infinitely and is therefore a continuous variable. After considerable deliberation about selecting levels of visibility and about the interaction between visibility and the day/night variable, we asked the question, "What aspects of target visibility are most likely to affect a crew's effectiveness (likelihood of a hit, performance time, or both) in neutralizing targets?" The answer to this question lay, not in whether a day or night

engagement was involved, but in two other considerations: whether or not artificial light was required to make the target visible, and whether or not the target was visible under any circumstances at all. Thus, the levels of the visibility variable selected for inclusion in the study were:

1. Visible without artificial light.
2. Visible with artificial light.
3. Not visible under any circumstances.

Target Range. The pervasive consideration in selecting levels of the target range variable was to minimize the number of levels (and therefore the number of objectives) while still reflecting the maximum effective ranges of the weapons, fire control instruments, and ammunition that would be included in the objectives. The levels of target ranges selected, and rationales for their selection were:

1. <500 meters: the ranges within which the rangefinder should not be used.
2. 500-900 meters: the ranges within which the TC must range.
3. <900 meters: the ranges within which the coax is effective.
4. <1100 meters: the ranges within which IR is effective; also, 1100 meters is the battlesight range indexed for HEAT.
5. 1100-1600 meters: 1600 meters is the battlesight range indexed for SABOT. 1100 meters was established as a lower range parameter for convenience in combining job objectives for SABOT and HEAT at <1100 meters (see Tables 1 through 7).
6. 500-3200 meters: The rangefinder is effective at 500 through 4400 meters. But because some of our objectives are to be performed both by the TC using the rangefinder, and the CMR using the telescope, an upper range of 3200 was established to reflect the maximum effective range of the telescope.

7. 1100-2300 meters: the ranges within which the caliber .50 machinegun may be used with white light or illuminating shells.

8. 1100-3200 meters: the ranges within which the main gun may be used with white light or illuminating shells.

9. ALL: the ranges within which the main gun may be used with range card data.

Ammunition. Ammunition is another discrete variable, for which levels were selected by identifying the kinds of ammunition customarily available for use with the main gun, coax, and caliber .50 machinegun: SABOT (APDS), HEAT, HEP, BEEHIVE (APERS), COAX (7.62mm) and CALIBER .50.

Day/Night. Two levels of this condition were selected -- day and night -- after considerable debate about its utility. The day/night variable is both redundant to, and less descriptive than, the levels of the visibility condition. It is redundant in that gunnery operations will be the same whether the target is visible without artificial light at night or visible without artificial light in the daytime; and operations will be the same whether the target is not visible under any circumstances at night or not visible under any circumstances in the daytime. The day/night variable is less descriptive than the visibility variable in that it does not distinguish between targets that are or are not visible in the daylight, or between targets that are or are not visible without artificial illumination at night .

Despite the reservations noted above, we decided to retain the day/night condition for use in our job objectives, mainly to make

comparisons possible between the job objectives and the day/night training exercises proposed in TC 17-12-5.

Figure 3 summarizes the conditions and levels within conditions that resulted from the exercise described above.

Combining Levels Across Conditions

Using the conditions and the levels within conditions as summarized in Figure 2, it is possible to form a very large number of tank gunnery objectives by selecting one level from each condition, and combining it with one level from every other condition. The number of possible combinations equals the number of levels within each condition multiplied together, or 3 (weapons) x 4 (fire-delivery methods) x 2 (crew members) x 9 (fire control instruments) x 2 (firing vehicle motions) x 2 (target motions) x 5 (target types) x 3 (target visibility conditions) x 9 (target ranges) x 6 (kinds of ammunition) x 2 (day/night conditions) = 1,679,616. While the number of possible combinations of levels within conditions is large, the great majority of combinations do not in fact "make sense" -- combinations, for example, that have the gunner firing the caliber .50 machinegun, or where the target is a moving bunker, or where the tank commander is using the gunner's periscope. Notice that it is not necessary to write and examine each possible combination of levels of conditions before discarding the nonsensical combinations. Objectives simply are not written for any subsets of combinations that have two levels that do not "go together."

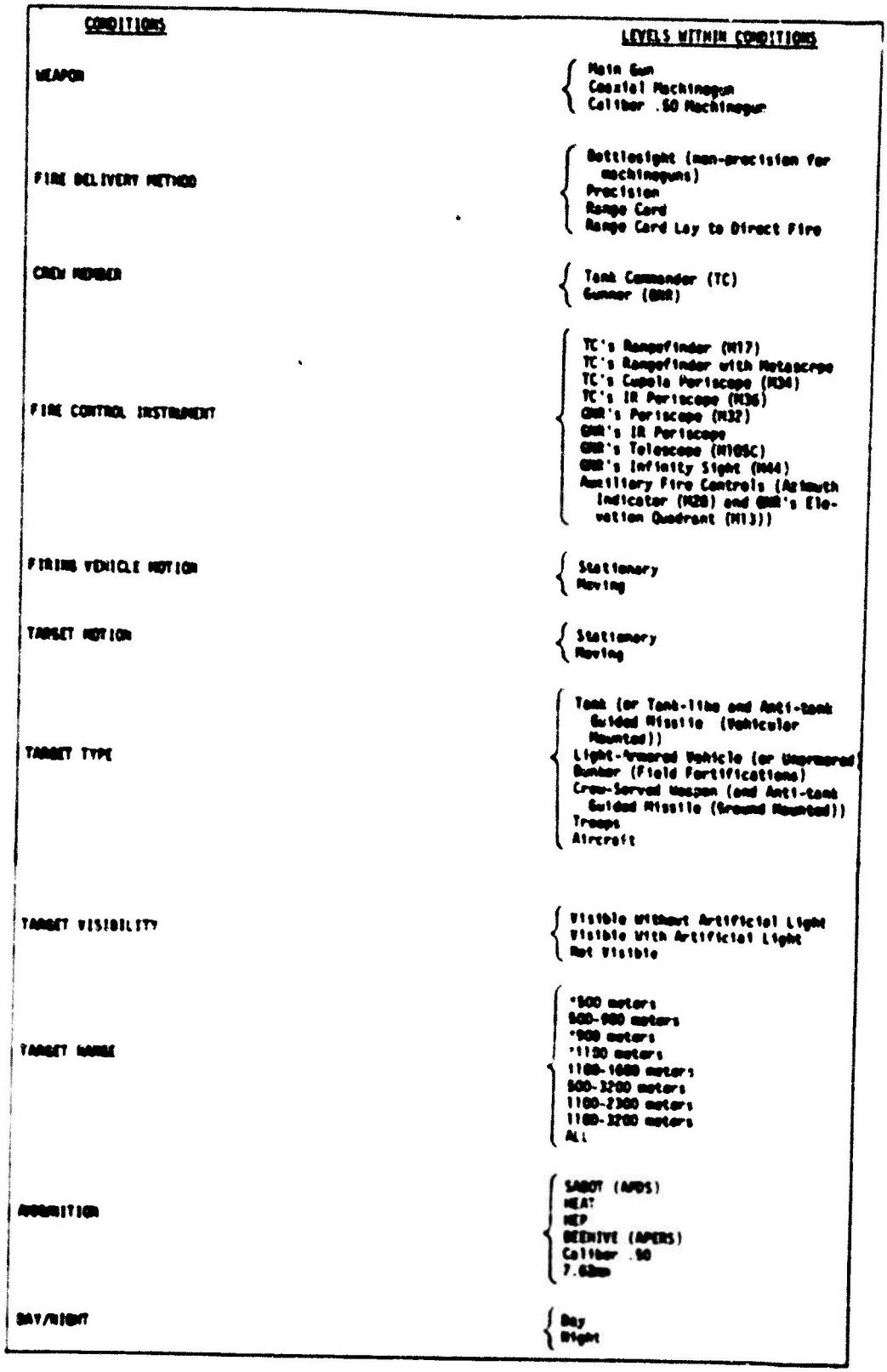


FIG. 2. Conditions and levels within conditions for use in the job objectives.

By ignoring the combinations of conditions levels that did not make sense, and by combining some levels within conditions (tank and light-armored vehicle targets for some main gun engagements, for example), we identified 225 combinations of levels across conditions, under which M60A1AOS tank crews might be expected to neutralize targets in the "real world." By pairing each of the 225 combinations with the general statement of the gunnery task (neutralize targets), we had the basis for writing 225 different job objectives for tank gunnery.

The criterion for calling an objective unique or different, and including it in the list of 225, was that the manipulations required on the part of the crew member who was doing the firing had to be different in some respect from the manipulations required in all other objectives. Thus, firing at stationary and moving targets with the main gun were considered different or unique objectives (because different manipulations are involved). But firing battlesighted SABOT or HEAT at a tank at less than 1100 meters was treated as a single objective (no difference in the gunner's manipulations, even though two different kinds of ammunition are used).

Specifying Standards

The goal for this part of the project was to establish performance standards for each of the 225 job objectives. The standards were to be more complete and explicit than those customarily set forth by training developers, in that they would be characterized by separate measures of:

1. Performance quality.

2. Production.

3. Cost.

Performance Quality. The measure of performance quality in gunnery is accuracy: hitting target centers constitutes higher quality gunnery performance than missing targets. For purposes of this project, "target hit" was the quality measure associated with each objective. No distinctions were made with respect to "goodness of hit," and all hits were assumed to result in neutralized targets. We realize that these assumptions are indefensible, but chose to accept them as the only alternative to the time-consuming hair-splitting that would be involved in specifying different time standards for hits which did, as opposed to hits which did not, neutralize targets.

Production. The measure of production for each job objective is one hit, regardless of target characteristics or of weapons used; that is, one is the minimally acceptable number of hits to be gotten within the time and ammunition-expenditure constraints for each objective. In machinegun engagements, a minimum of one tracer must hit the target. (One in five rounds is a tracer.)

Cost. As noted earlier, the "cost" allowable for achieving the performance quality and production criteria was to be specified in terms of performance time, and number of rounds expended.

The method for establishing the maximum number of rounds to be expended in the engagements described by our job objectives was subjective. The results represent a compromise among existing practice

in training, recent actuarial data on simulated tank combat, and what our subject-matter experts thought was reasonable. The maximum numbers of rounds to be expended in the engagements described by our job objectives are:

1. Two rounds for all main gun engagements, except for range card firing in which five rounds are allowed.
2. One-hundred fifty rounds for coaxial and caliber .50 machinegun engagements against area targets.
3. Sixty rounds for coax engagements against point targets.
4. Fifty rounds for caliber .50 machinegun engagements against point targets.

Tentative performance time standards were established by the three subject-matter experts on the project staff, who reviewed the 225 objectives and specified opening and total times for each. A Tank Gunnery Panel was then convened, which consisted of two gunnery instructors from the US Army Armor School, Weapons Department; and one tank commander from the US Army Research Institute detachment at Fort Knox. The three members of the panel were former tank commanders, with 18 months, 6 years, and 9 years experience.

The panel members were given a briefing on the objectives of the project and their role in it; and were asked to specify opening and closing times for an "average" tank crew, for each engagement described by the job objectives. As a means of structuring their assignment further, we also gave the panel members a list of assumptions that had been prepared by the project's subject-matter experts while developing their preliminary time estimates. The list of assumptions is attached as Appendix A to this report.

The panel spent three days specifying opening and closing times for the job objectives. A project staff member was present throughout the meetings to answer questions, and to assist by providing copies of pertinent gunnery publications. He made no effort to influence the panel's decisions, which were made on the basis of the panel members' own experience and the contents of the literature at their disposal. Where differences of opinion arose in specifying the time standards, they were debated by the panel members and resolved. The final list of time standards had the unanimous approval of the panel.

After doing their time estimates, the panel members met with the HumRRO subject-matter experts to resolve differences between the two independently generated sets of estimates. For objectives where the difference between the two groups' opening or closing time estimates was four seconds or less, a compromise standard was set by splitting the difference. In cases where the time difference was greater than four seconds, a time-line analysis was done, assigning a time to each component "step" in the engagement. Consensus on opening and total times was reached after discussions about the time required for each component step. An ancillary benefit of the time-line analysis was a table of "Constants used in Estimating Performance Times," which evolved as a result of the groups' discussions. The table is presented as Appendix B of this report.

Results

The job objectives resulting from applying the methods just described are presented in Tables 1 through 7. The objectives are presented in tabular, as opposed to narrative form, to facilitate

TABLE I

JOB OBJECTIVES: MAIN GUN, BATTLESIGHT

JOB OBJECTIVE NUMBER		FIRE VEH MOTION	TARGET				DAY OR NGT	FIRE CONTROL INSTRUMENTS										AMMO	PERFORMANCE TIME (SEC)			
			MOTION	TYPE	VISIBILITY	RANGE (METERS)*		RFDR		TC/PER		GNR/PER		EL	TMF	AUX		TC		GNR	
TC	GNR							D	IR	D	IR	D	IR					OPER	TOTAL	OPER	TOTAL
1	1,2	STA	STA	T/L	VIS	-1100	D/N	1				1		2			SB/HT	10	15	7	12
2	3,4	MOV	STA	T/L	VIS	-1100	D/N	1				1		2			SB/HT	13	18	10	15
3	5,6	STA	MOV	T/L	VIS	-1100	D/N	1				1		2			SB/HT	13	18	10	15
4	7,8	MOV	MOV	T/L	VIS	-1100	D/N	1				1		2			SB/HT	16	21	13	18
5,6	9,10,11	STA	STA	T/L	VAL	-1100	NGT	1	2			3	1	4			SB/HT	20	27	17	24
7,8	12,13,14	MOV	STA	T/L	VAL	-1100	NGT	1	2			3	1	4			SB/HT	23	30	20	27
9,10	15,16,17	STA	MOV	T/L	VAL	-1100	NGT	1	2			3	1	4			SB/HT	23	30	20	27
11,12	18,19,20	MOV	MOV	T/L	VAL	-1100	NGT	1	2			3	1	4			SB/HT	26	33	23	30
1	1,2	STA	STA	TNK	VIS	11-1600	D/N	1				1		2			SABOT	10	17	7	14
2	3,4	MOV	STA	TNK	VIS	11-1600	D/N	1				1		2			SABOT	13	20	10	17
3	5,6	STA	MOV	TNK	VIS	11-1600	D/N	1				1		2			SABOT	13	20	10	17
4	7,8	MOV	MOV	TNK	VIS	11-1600	D/N	1				1		2			SABOT	16	23	13	20
5	9,11	STA	STA	TNK	VAL	11-1600	NGT	1				1		2			SABOT	15	24	12	21
7	12,14	MOV	STA	TNK	VAL	11-1600	NGT	1				1		2			SABOT	18	27	15	24
9	15,17	STA	MOV	TNK	VAL	11-1600	NGT	1				1		2			SABOT	18	27	15	24
11	18,20	MOV	MOV	TNK	VAL	11-1600	NGT	1				1		2			SABOT	21	30	18	27

*Where lower and upper range limits are given, add two zeros to the lower limit: 11-1600 = 1100-1600 meters.

TABLE 2

JOB OBJECTIVES: MAIN GUN, PRECISION

JOB OBJECTIVE NUMBER		FIRE VEH MOTION	TARGET				DAY OR NGT	FIRE CONTROL INSTRUMENTS										AMMO	PERFORMANCE TIME (SEC)			
			MOTION	TYPE	VISIBILITY	RANGE* (METERS)		RFDR		TC/PER		GNR/PER		TEL	INF	AUX		TC		GNR	
TC	GNR							D	IR	D	IR	D	IR						OPEN	TOTAL	OPEN	TOTAL
1	1,2	STA	STA	T/L	VIS	5-3200	D/N	3				1		2				SB/HT	13	21	10	19
	3,4	MOV	STA	T/L	VIS	5-3200	D/N					1		2				SB/HT			13	22
	5,6	STA	MOV	T/L	VIS	5-3200	D/N					1		2				SB/HT			13	22
	7,8	MOV	MOV	T/L	VIS	5-3200	D/N					1		2				SB/HT			16	25
2	9,10	STA	STA	T/L	VAL	5-3200	NGT	3				1		2				SB/HT	18	28	15	26
	11,12	MOV	STA	T/L	VAL	5-3200	NGT					1		2				SB/HT			18	29
	13,14	STA	MOV	T/L	VAL	5-3200	NGT					1		2				SB/HT			18	29
	15,16	MOV	MOV	T/L	VAL	5-3200	NGT					1		2				SB/HT			21	32
3	17,2	STA	STA	B/C	VIS	5-3200	D/N	3				2		1				HEP	15	27	12	25
	18,4	MOV	STA	B/C	VIS	5-3200	D/N					2		1				HEP			15	28
4	19,10	STA	STA	B/C	VAL	5-3200	NGT	3				2		1				HEP	20	34	17	32
	20,12	MOV	STA	B/C	VAL	5-3200	NGT					2		1				HEP			20	35
1	1,21	STA	STA	TRP	VIS	5-3200	D/N	3				1		2				B/HIVE	21	38	18	36
	3,22	MOV	STA	TRP	VIS	5-3200	D/N					1		2				B/HIVE			21	39
2	9,23	STA	STA	TRP	VAL	5-3200	NGT	3				1		2				B/HIVE	26	45	26	46
	11,24	MOV	STA	TRP	VAL	5-3200	NGT					1		2				B/HIVE			29	49

*Where lower and upper range limits are given, add two zeros to the lower limit: 11-1600 = 1100-1600 meters.

TABLE 3

JOB OBJECTIVES: MAIN GUN, RANGE CARD, AND RANGE CARD LAY TO DIRECT FIRE

JOB OBJECTIVE NUMBER		FIRE VEH MOTION	TARGET				DAY OR NGT	FIRE CONTROL INSTRUMENTS									AMMO	PERFORMANCE TIME (SEC)			
								RFDR		TC/PER		GNR/PER						TC		GNR	
TC	GNR		MOTION	TYPE	VISIBILITY	RANGE (METERS)		D	IR	D	IR	D	IR	FIL	TRF	AUX		OPER	TOTAL	OPER	TOTAL
RANGE CARD																					
	1	STA	STA	ALL	WPS	ALL	D/N									1	MEP			30	55
RANGE CARD LAY TO DIRECT FIRE																					
1,2	1,2,3	STA	STA	T/L	VAL	-1100	NGT	5	2			3	1	4		*	SB/HT	40	48	40	48
3,4	4,5,6	STA	MOV	T/L	VAL	-1100	NGT	5	2			3	1	4		*	SB/HT	43	51	43	51
1	1,3	STA	STA	T/L	VAL	11-3200	NGT	3				1		2		*	SB/HT	38	49	38	49
3	4,6	STA	MOV	T/L	VAL	11-3200	NGT	3				1		2		*	SB/HT	41	52	41	52
1,2	1,2,3	STA	STA	B/C	VAL	-1100	NGT	5	2			4	1	3		*	MEP	40	49	40	49
5	7,3	STA	STA	B/C	VAL	11-3200	NGT	3				2		1		*	MEP	40	55	40	55
1,2	1,2,8	STA	STA	TRP	VAL	-1100	NGT	5	2			4	1	3		*	B/HIVE	40	56	40	56
1	7,8	STA	STA	TRP	VAL	11-3200	NGT	3				2		1		*	B/HIVE	40	60	40	60

*Where lower and upper range limits are given, add two zeros to the lower limit: 11-1600 = 1100-1600 meters.

TABLE 9

JOB OBJECTIVES: COAXIAL MACHINEGUN, NON-PRECISION

JOB OBJECTIVE NUMBER		FIRE VEH MOTION	TARGET				DAY OR NGT	FIRE CONTROL INSTRUMENT'S									AMMO	PERFORMANCE TIME (SEC)			
			MOTION	TYPE	VISIBILITY	RANGE* (METERS)		RFDR		TC/PER		GNR/PER		TEL	INF	AUX		TC		GNR	
TC	GNR							D	IR	D	IR	D	IR					OPEN	TOTAL	OPEN	TOTAL
1	1,2,3	STA	STA	L/C	VIS	-500	D/N	3				1		4	2		COAX	11	21	8	18
2	4,5,6	MOV	STA	L/C	VIS	-500	D/N	3				1		4	2		COAX	14	24	11	21
3,4	7,8,9,10	STA	STA	L/C	VAL	-500	NGT	5	2			3	1	6	4		COAX	21	31	18	28
5,6	11,12,13,14	MOV	STA	L/C	VAL	-500	NGT	5	2			3	1	6	4		COAX	24	34	21	31
7	15,16,17	STA	MOV	LAV	VIS	-500	D/N	3				1		4	2		COAX	14	24	11	21
8	18,19,20	MOV	MOV	LAV	VIS	-500	D/N	3				1		4	2		COAX	17	27	14	24
9,10	21,22,23,24	STA	MOV	LAV	VAL	-500	NGT	5	2			3	1	6	4		COAX	24	34	21	31
11,12	25,26,27,28	MOV	MOV	LAV	VAL	-500	NGT	5	2			3	1	6	4		COAX	27	37	24	34
13	29,30,31	STA	STA	TRP	VIS	-500	D/N	3				2		4	1		COAX	11	36	8	33
14	32,33,34	MOV	STA	TRP	VIS	-500	D/N	3				2		4	1		COAX	14	39	11	36
15,16	35,36,37,38	STA	STA	TRP	VAL	-500	NGT	5	2			4	1	6	3		COAX	21	46	18	43
17,18	39,40,41,42	MOV	STA	TRP	VAL	-500	NGT	5	2			4	1	6	3		COAX	24	49	21	46

*Where lower and upper range limits are given, add two zeros to the lower limit: 11-1600 = 1100-1600 meters.

TABLE 5

JOB OBJECTIVES: COAXIAL MACHINEGUN, PRECISION

JOB OBJECTIVE NUMBER		FIRE VEH MOTION	TARGET				DAY OR NGT	FIRE CONTROL INSTRUMENTS										AMMO	PERFORMANCE TIME (SEC)			
								RFDR		TC/PER		GNR/PER		T E L	T R F	A U X			TC		GNR	
TC	GNR		MOTION	TYPE	VISIBILITY	RANGE (METERS)*		D	IR	D	IP	D	IR						OPER	TOTAL	OPER	TOTAL
1	1,2,3	STA	STA	L/C	VIS	5-900	D/N	3				1		4	2		COAX		14	24	11	21
	4,5,6	MOV	STA	L/C	VIS	5-900	D/N					1		3	2		COAX				14	24
2	7,8,9	STA	STA	L/C	VAL	5-900	NGT	3				1		4	2		COAX		19	29	16	26
	10,11,12	MOV	STA	L/C	VAL	5-900	NGT					1		3	2		COAX				19	29
	13,14,15	STA	MOV	LAV	VIS	5-900	D/N					1		3	2		COAX				14	24
	16,17,18	MOV	MOV	LAV	VIS	5-900	D/N					1		3	2		COAX				17	27
	19,20,21	STA	MOV	LAV	VAL	5-900	NGT					1		3	2		COAX				19	29
	22,23,24	MOV	MOV	LAV	VAL	5-900	NGT					1		3	2		COAX				22	32
3	25,26,27	STA	STA	TRP	VIS	5-900	D/N	3				2		4	1		COAX		14	39	11	36
	28,29,30	MOV	STA	TRP	VIS	5-900	D/N					2		3	1		COAX				14	39
4	31,32,33	STA	STA	TRP	VAL	5-900	NGT	3				2		4	1		COAX		19	45	16	41
	34,35,36	MOV	STA	TRP	VAL	5-900	NGT					2		3	1		COAX				19	44

*Where lower and upper range limits are given, add two zeros to the lower limit: 11-1600 = 1100-1600 meters.

TABLE 6

JOB OBJECTIVES: COAXIAL MACHINEGUN, RANGE CARD, AND RANGE CARD LAY TO DIRECT FIRE

JOB OBJECTIVE NUMBER		FIRE VEH MOTION	TARGET				DAY OR NGT	FIRE CONTROL INSTRUMENTS									AMMO	PERFORMANCE TIME (SEC)			
			POSITION	TYPE	VISIBILITY	RANGE (METERS)		RFDR		TC/PER		GNR/PER		VEL	TRF	AUX		TC		GNR	
TC	GNR							D	IR	D	IR	D	IR					OPER	TOTAL	OPER	TOTAL
RANGE CARD																					
	1	STA	STA	L/C/T	RVS	<900	D/N									1	COAX			30	55
RANGE CARD LAY TO DIRECT FIRE																					
1,2	1,2,3,4	STA	STA	L/C	VAL	<500	NGT	5	2			3	1	6	4	*	COAX	40	50	40	50
3	5,6,7	STA	STA	L/C	VAL	5-900	NGT	3				1		4	2	*	COAX	38	48	38	48
4,5	8,9,10,11	STA	MOV	LAV	VAL	<500	NGT	5	2			3	1	6	4	*	COAX	43	53	43	53
6	12,13,14	STA	MOV	LAV	VAL	5-900	NGT	3				1		4	2	*	COAX	41	51	41	51
7,8	15,16,17,18	STA	STA	TRP	VAL	<500	NGT	5	2			4	1	6	3	*	COAX	40	65	40	65
9	19,20,21	STA	STA	TRP	VAL	5-900	NGT	3				2		4	1	*	COAX	38	63	38	63

*Where lower and upper range limits are given, add two zeros to the lower limit: 11-1600 = 1100-1600 meters.

TABLE 7

JOB OBJECTIVES: CALIBER .50 MACHINEGUN, NON-PRECISION

JOB OBJECTIVE NUMBER		FIRE VEH MOTION	TARGET				DAY OR NGT	FIRE CONTROL INSTRUMENTS										AMMO	PERFORMANCE TIME (SEC)			
								M/CM		TC/PER		GNR/PER		E L	A F	R U			TC		GNR	
TC	GNR		POSITION	TYPE	VISIBILITY	RANGE* (METERS)		D	ID	D	ID	D	ID						OPEN	TOTAL	OPEN	TOTAL
1		STA	STA	L/C	VIS	.2300	D/N			1								CAL 50	7	16		
2		MOV	STA	L/C	VIS	.2300	D/N			1								CAL 50	10	19		
3,4		STA	STA	L/C	VAL	.1100	NGT			2	1							CAL 50	17	26		
5,6		MOV	STA	L/C	VAL	.1100	NGT			2	1							CAL 50	20	29		
3		STA	STA	L/C	VAL	11-2300	NGT			1								CAL 50	12	21		
5		MOV	STA	L/C	VAL	11-2300	NGT			1								CAL 50	15	24		
7		STA	MOV	LAV	VIS	.2300	D/N			1								CAL 50	10	19		
8		MOV	MOV	LAV	VIS	.2300	D/N			1								CAL 50	13	22		
9,10		STA	MOV	LAV	VAL	.1100	NGT			2	1							CAL 50	20	29		
11,12		MOV	MOV	LAV	VAL	.1100	NGT			2	1							CAL 50	23	32		
9		STA	MOV	LAV	VAL	11-2300	NGT			1								CAL 50	15	24		
11		MOV	MOV	LAV	VAL	11-2300	NGT			1								CAL 50	18	27		
13		STA	STA	TRP	VIS	.2300	D/N			1								CAL 50	7	30		
14		MOV	STA	TRP	VIS	.2300	D/N			1								CAL 50	10	33		
15,16		STA	STA	TRP	VAL	.1100	NGT			2	1							CAL 50	17	40		
17,18		MOV	STA	TRP	VAL	.1100	NGT			2	1							CAL 50	23	43		
15		STA	STA	TRP	VAL	11-2300	NGT			1								CAL 50	12	35		
17		MOV	STA	TRP	VAL	11-2300	NGT			1								CAL 50	15	38		
19		STA	MOV	AIR	VIS	.2300	DAY			1								CAL 50	10	14		
20		MOV	MOV	AIR	VIS	.2300	DAY			1								CAL 50	15	19		

*Where lower and upper range limits are given, add two zeros to the lower limit: 11-1600 = 1100-1600 meters.

comparisons among conditions and among standards. The objectives are available in narrative form from ARI (Kraemer, et al., 1975).

Organization of the Job Objectives

The main organizer for the job objectives in Tables 1 through 7 is the weapon: main gun, coaxial machinegun, and caliber .50 machinegun. Within each of the three weapon systems, the objectives are further organized by method of fire delivery. The overall organization of the tables is as follows:

Table 1: Main Gun, Battlesight.

Table 2: Main Gun, Precision.

Table 3: Main Gun, Range Card, and Range Card Lay to Direct Fire.

Table 4: Coax, Non-precision.

Table 5: Coax, Precision.

Table 6: Coax, Range Card, and Range Card Lay to Direct Fire.

Table 7: Caliber .50, Non-precision.

Reading the Objectives

Consider the first entry in Table 1 (Main Gun, Battlesight): The entries under JOB OBJECTIVE NUMBER indicate that the first row in the table summarizes Job Objective #1 for the tank commander (TC) and two job objectives - [illegible]2 -- for the gunner (GNR). Underscored numbers in the JOB OBJECTIVE NUMBER columns indicate job objectives that are addressed by the gunnery tables proposed in TC 17-12-5 (October 1974). The underscoring can be ignored for now, but will be referred

to later in comparisons between the job objectives and the gunnery exercises.

To understand the job-objective numbering system in Tables 1 through 7, it is necessary to consider the entries under the heading FIRE CONTROL INSTRUMENTS:

1. RFDR (rangefinder), D (day), and IR (infrared).
2. TC/PER (tank commander's periscope), Day and IR.
3. GNR/PER (gunner's periscope), Day and IR.
4. TEL (telescope).
5. INF (infinity sight).
6. AUX (auxiliary fire control instruments).

The numbers under these headings indicate the order of preference for use of the fire control instrument in engaging targets described in the row. The 1 under GNR/PER, D, indicates that the gunner's day periscope is the primary fire control instrument to be used for engaging targets described in the first row. The number 2 under TEL indicates that the telescope is a secondary fire control instrument that the gunner may use in engaging such targets. And the entry, 3, under RFDR, D, indicates that the rangefinder (day) may be used by the TC as a third alternate system. The first row in the table, then, summarizes three job objectives:

1. GNR's Job Objective #1: Engaging targets described in the row, using the gunner's day periscope.
2. GNR's Job Objective #2: Engaging targets described in the row, using the gunner's telescope.
3. TC's Job Objective #1: Engaging targets described in the row, using the rangefinder.

Notice that some job objectives are repeated in Tables 1 through 7. TC's Job Objective #1 appears twice in Table 1, for example. The reason for repeating some objectives is that at least one condition in the objective changes, and this change has an effect on performance time: TC's Job Objective #1 is repeated in Table 1 because the range is different for the two entries, and the range change makes the total performance time different. The change in total performance time, though, is due only to the different distances that the rounds must travel, and has nothing to do with the performance of the TC. Recall that to qualify as unique, an objective had to require manipulations that were different from the manipulations in all other objectives. Since the same manipulations are involved in firing TC's Job Objective #1 at ranges of less than 1100 meters and at ranges between 1100 and 1600 meters, the two entries are treated as the same objective.

The entry, STA, in the first row under the FIRE VEH MOTION column in Table 1 indicates that the firing vehicle is stationary.

Target characteristics for the first entry of Table 1 are:

1. STA: stationary.
2. T/L: tank or light-armored vehicle.
3. VIS: visible without artificial light.
4. <1100: less than 1100 meters.

D/N indicates that the objective is to be performed either during the day or at night.

SB/HT indicates that SABOT or HEAT is to be used.

The PERFORMANCE TIME entries in Tables 1 through 7 give opening and total times for the TC and GNR. In cases where the row contains only one objective for either the TC or GNR, the opening and total times for that objective are given. The first entry in Table 1, for example, contains only one objective for the TC (using the range-finder). The performance time for this objective is given under TC, OPEN, TOTAL: 10 seconds to open, and 15 seconds total.

In cases where the row contains more than one objective for either the TC or GNR, the opening and total times are given only for the engagement using the primary fire control instruments. The first entry in Table 1 contains two objectives for the GNR: the primary objective, using the day periscope; and the secondary objective, using the telescope. The 7-second opening, and 12-second total times in the first row under GNR, OPEN, TOTAL are for the primary (gunner's periscope) objective. No performance times are given in the table for the gunner's Job Objective #2 (using the telescope). Performance times for the secondary or alternate fire-control instruments were computed using the constants in Appendix B. They are presented under separate cover in the narrative forms of the objectives (see Kraemer, et al., 1975).

The performance times given in the job objective tables are for the maximum range specified in the objective. If, for example, the range specified in the objective is 11-1600 (1100 to 1600 meters), the performance times shown in the objective apply to the 1600-meter upper limit. Performance times for ranges less than the upper limit can be computed using data presented in Firing Tables, FT 105-A-2.

The quality, production, and number of rounds were left out of Tables 1 through 7 to avoid redundancy. Recall that the production and quality measure is "one hit" for each objective, and that the maximum number of rounds to be expended is:

1. Two for all main gun engagements, except for range card objectives.

2. Five for main gun, range card objectives.

3. Sixty for coax, and fifty for caliber .50 point targets.

4. One-hundred-fifty for coax and caliber .50 area targets.

Using the information given above, the three objectives in the first row of Table 1 can be written as:

. TC Objective #1: Given (a) a stationary M60A1AOS tank with the main gun battlesighted with SABOT or HEAT, (b) an operational rangefinder, and (c) a stationary tank or light-armored vehicle target that is visible at less than 1100 meters without artificial light at day or night; TC will open fire within 10 seconds of the alert element of his command, and neutralize the target within 15 seconds, using no more than two rounds.

. GNR Objective #1: Given (a) a stationary M60A1AOS tank with the main gun battlesighted with SABOT or HEAT, (b) an opertional gunner's day periscope, and (c) a stationary tank or light-armored vehicle target that is visible at less than 1100 meters without artificial light at day or night; GNR will open fire within 7 seconds of the alert element of the TC's command, and neutralize the target within 12 seconds, using no more than two rounds.

. GNR Objective #2: Given (a) a stationary M60A1AOS tank with the main gun battlesighted with SABOT or HEAT, (b) an oparational telescope (day), and (c) a stationary tank or light-armored vehicle target that is visible at less than 1100 meters without artificial light at day or night; GNR will open fire within 9 seconds of the alert element of the TC's command, and neutralize the target within 14 seconds, using no more than two rounds.

A numerical summary of 225 job objectives, by weapon, fire delivery method, and crew member is presented in Table 8.

Discussion

The parts of the job objectives pertaining to activities or tasks, conditions, and standards raise separate issues for discussion.

Activities or Tasks

Traditionalists, schooled in the means and ends of task analysis, undoubtedly will take issue with our definition of the gunnery job in terms of one "task" -- neutralizing targets. Certainly the job is more complex than that. We agree that it is, and suggest that this complexity has been reflected, not in the usual detailed list of task statements, but in the myriad combinations of conditions presented in the job objectives. We suggest also that the test of the adequacy of any set of job objectives is neither the number of different tasks included in the set, nor the level of detail at which the tasks are written. Rather, the test of adequacy is comprehensiveness.

The question of comprehensiveness, as applied to the job objectives presented in this report, reduces to the question, "Are there ways, other than those described by the objectives, that targets can be neutralized with M60A1AOS guns?" We think not. And if not, then the job objectives provide a data base from which developing training and evaluation programs can proceed.

Further on the topic of comprehensiveness: Our job objectives are intended to describe gunnery comprehensively. In the term, "gunnery

TABLE 8

NUMBERS OF JOB OBJECTIVES, BY WEAPON, FIRE DELIVERY METHOD, AND CREW MEMBER

WEAPON / FIRE DELIVERY METHOD	MAIN GUN		COAX		CAL .50	TOTALS
	TC	GNR	TC	GNR	TC	
Battlesight (non-precision for machineguns)	12	20	18	42	20	112
Precision	4	24	4	36		68
Range Card		1		1		2
Range Card Lay to Direct Fire	5	8	9	21		43
TOTALS	21	53	31	100	20	225

job objectives," the important qualifier is "gunnery." It is used synonymously with "marksmanship" or "shooting." The job objectives do not deacribe comprehensively the gunner's job, which consiats of tasks other than those encompassed by gunnery -- maintenance tasks, for example, and computer checks.

Conditions

A possible criticism of the conditions parts of the job objectives is that some conditions that will affect crews' ability to neutralize targets have not been included in the objectives. Conditions such as enemy firepower and tactics, and presence or absence of air and artillery support are examples. This line of criticism loses sight of the goals of gunnery training and of the purposes of this project. The purpose of this project was to compare gunnery job objectives and training content. And the goal of gunnery training (through Tables VII and VIII) is to teach crews to neutralize targets with minimal expenditures of time and ammunition. Current and proposed gunnery training do not include firing in the presence of air and artillery support, or against multiple, tactically deployed targeta. Engagements under theae kinds of conditions are seen as a body of akill and knowledge outside the realm of "gunnery" or "marksmanship," and within the realm of fire control and command -- topics that are addreased in Gunnery Tables IX and X.

Standards

Whether or not two rounds are the "right" allocationa for main gun engagements, or whether a TC needs to hit a target only once while

firing 150 caliber .50 rounds, or whether or not our opening and total times are "correct" are open questions. Gunnery standards, and standards for all combat performance, should not be set on the basis of expert judgment, for if the experts are wrong, our gunners will be in trouble "when the flag drops." Nor should standards be set on the basis of the normative performance of our own trainees or qualified gunners. Normative data can tell us how good we are, but not how good we need to be. Standards for combat performance should be set on the basis of the best available information about the enemy's capability. Knowing that our gunners can meet arbitrarily established opening and closing time standards of 5 and 7 seconds provides little comfort if the enemy can open in 4 seconds and close in 6. Information about enemy gunnery capabilities must be made available to guide development of training and job performance standards.

Conclusion

The gunnery job objectives developed during this project seem comprehensive. It is difficult to think of ways, other than those described in the objectives, that crews could neutralize targets with M60A1AOS guns. One may argue that the task or activity statements used in the objectives are "too general," or that certain conditions that affect gunnery performance have been omitted, or that performance standards based on expert judgment are (or are not) totally satisfactory. The counter-arguments have been presented, and the issues defy rapid resolution. But if the job objectives are comprehensive, then a basis has been provided for:

A. Comparing the content of proposed gunnery training to gunnery job content. This in turn permits comparing what will be included in gunnery training and what will be excluded.

B. Developing efficient gunnery training. By specifying the component skills in the gunnery job objectives, and then identifying component skills that cut across objectives, a basis will be provided for specifying enabling training objectives. Mastery of the enabling objectives should promote learning of the maximum number of job objectives.

C. Developing training for crews of tanks other than the M60A1AOS. The job objectives for the M60A1AOS can be rewritten to form a comprehensive set of job objectives for any new tank, by replacing any conditions and levels within conditions that are unique to the M60A1AOS with conditions and levels that apply to the new tank.

D. Evaluating the effectiveness of gunnery training. The job objectives generated during this project can be used to develop gunnery evaluation programs that will permit a high degree of confidence in results. Assuming that the purpose of gunnery training is to permit crews to neutralize targets in all the ways described by the objectives, random selection of job objectives for use as "test items" would be one way to design valid measures of training effectiveness. The pool of objectives could be reduced before item selection took place by deleting objectives that are too costly to test (aircraft targets, for example), or job objectives could be selected for use in evaluation, on the basis of criticality, difficulty, or frequency of performance. The item pool is now available. How it is used is a policy matter.

Notice also that by accumulating data on performance of the objectives over time, a basis will be provided for applying all of the traditional methods of item analysis. Answers to questions such as "Does a 'GO' on item X guarantee a 'GO' on item Y?" need no longer be subject to the vagaries of expert opinion.

GUNNERY EXERCISES AND TRAINING OBJECTIVES

This part of the project dealt with translating the tank gunnery exercises presented in Firing Tables I through VIII of TC 17-12-5 (October 1974) into the format of human performance objectives. This was done in order to make comparisons possible between training content and the job objectives developed earlier in the project.

Orientation: Firing Tables and Exercises

Training Circular (TC) 17-12-5 is a document that reflects emerging doctrine and thinking with respect to tank gunnery training. Training content is organized within eight firing tables, each of which contains several training exercises. Tank crews progress through the exercises in Tables I through VII on their way to qualifying by firing the exercises in Table VIII.

TC 17-12-5 is being revised, and eventually may become a field manual (FM) to replace FM 17-12. A major difference between training as prescribed in FM 17-12 and TC 17-12-5 is in method of fire delivery. The field manual emphasizes the precision method, in which crews range on the target and obtain a highly accurate gun lay in order to maximize the probability of a first-round hit. The new training circular retains some emphasis on the precision method of fire delivery, and adds battlesight, target-form, and burst-on-target -- "quick-draw" techniques that are designed to capitalize on the potential of tank weaponry for combining shock effect, accuracy, and speed.

The purposes of the eight gunnery firing tables in TC 17-12-5 include:

1. "... the development of individual skills by different crew members."

2. "... to develop solid individual expertise combined with teamwork within a crew."

3. "... to train individual members of a tank crew in a logical sequence culminating in crew qualifications and crew battle-runs."

The general goals of each of the eight tables are:

. Table I: Zero and manipulation techniques.

. Table II: Fundamentals of fire adjustment techniques.

. Table III: Tracking and applying proper adjustment techniques.

. Table IV. Zeroing the main gun, firing at stationary targets with the main gun with and without artificial illumination, and basic techniques of tank fire adjustment.

. Table V: Leading, tracking, engaging and adjusting fire on moving targets with the main gun with and without artificial illumination.

. Table VI: Develop crew coordination and ability to engage both moving and stationary targets with tank machineguns from a moving and stationary tank with and without artificial illumination.

. Table VII: Develop crew's ability to engage moving and stationary targets with all tank-mounted weapons with and without artificial illumination and to prepare the crew for testing on Table VIII.

. Table VIII: Qualification: Final evaluation of crew abilities developed during Table VII.

Tables VII and VIII are essentially identical, with practice on Table VII used to prepare crews for qualification on Table VIII.

The overall goals noted above are addressed by providing crews with practice in the following areas:

1. Day Firing. Referred to as "A" tables, these exercises are intended to train and evaluate the tank crew in the rapid destruction of targets during the day.

2. Night Firing. Referred to as "B" tables, these exercises are for training and evaluating the tank crew in the rapid engagement and destruction of targets at night under various methods of illumination, while instilling crew confidence in tank weapon effectiveness under conditions of darkness.

3. Subcaliber Firing. Referred to as "C" tables (Tables I, II and III), these exercises are designed to permit training and evaluating each crewman as a gunner without the distraction caused by the blast and recoil of the main gun. By simulating the firing of the main gun, gunnery procedures are practiced without expenditure of ammunition.

4. Dry Firing. Referred to as "D" tables, these exercises are designed to insure crewmen understand the fundamentals of gunnery, and to develop teamwork.

5. Service Firing (Tables IV and V). These exercises are for developing the skills, speed, and accuracy required by the tank commander, gunner, and loader in employing gunnery techniques against stationary and moving targets, and for conditioning the crew to the blast and recoil of the main gun.

6. Crew Field Firing and Crew Proficiency (Tables VI, VII and VIII). The purpose of these exercises is to train and test the speed and teamwork of the tank crew in engaging different targets at various ranges with the proper weapon and ammunition.

For purposes of orientation, a summary of the contents of Gunnery Tables I through VIII, by exercise number, method of fire delivery, and crew position (TC or GNR) from which each exercise is fired is presented in Table 9. The Arabic numbers after each cell entry correspond to the job objectives to which each training exercise is related. These numbers can be ignored now, but will be referred to later in comparing job and training objectives.

TABLE 9

GUNNERY EXERCISES BY METHOD OF FIRE DELIVERY, CREW POSITION, AND FIRING TABLE

EXERCISES			GUNNERY FIRING TABLES									
			I	II	III	IV	V	VI	VII		VIII	
									MAIN GUN	MACHINEGUN	MAIN GUN	MACHINEGUN
	1	A	Zero-GR (1)	BS-GR, 7	BS-GR, 5	BS-GR, 7	PRE-GR, 5	SQ-MP-TC, 7	BS-GR, 7	SQ-MP-TC, 7	BS-GR, 7	SQ-MP-TC, 7
		B		BS-GR, 9	BS-GR, 15	PRE-GR, 9	PRE-GR, 13	SQ-MP-TC, 8 (6)	BS-GR, 9	SQ-MP-TC, 8 (6)	BS-GR, 9	SQ-MP-TC, 8 (6)
	2	A	BS-GR, 1	BS-GR, 1	BS-GR, 6	PRE-GR, 1	PRE-GR, 5	CE-PRE-GR, 13	BS-GR, 1	CE-MP-GR, 34	BS-GR, 1	CE-MP-GR, 34
		B	BS-GR, 15	BS-GR, 9	BS-GR, 17	PRE-GR, 9 (2)	BS-GR, 15	CE-PRE-GR, 19	BS-GR, 9	CE-MP-GR, 40	BS-GR, 9	CE-MP-GR, 40
	3	A	BS-GR, 2	BS-GR, 1	BS-GR, 5	PRE-GR, 2	PRE-GR, 6	CE-MP-GR, 34	PRE-GR, 1	50-MP-TC; 14	PRE-GR, 1	50-MP-TC; 14
		B	BS-GR, 11	BS-GR, 15	BS-GR, 13	PRE-TC (3)	PRE-TC (3)	CE-MP-GR, 42	PRE-GR, 9	50-MP-TC, 17	PRE-GR, 9	50-MP-TC, 18
	4	A		BS-GR, 2	BS-GR, 6	BS-GR, 1	BS-GR, 5	CE-MP-GR, 34	BS-GR, 3	CE-PRE-GR, 13	BS-GR, 3	CE-PRE-GR, 13
		B	BC-GR, 1	BS-GR, 11	BS-GR, 11	PRE-TC (3)	PRE-GR, 11 (2)	CE-MP-GR, 40	BS-GR, 13	CE-PRE-GR, 19	BS-GR, 13	CE-PRE-GR, 19
	5	A		BS-GR, 2	BS-GR, 5	PRE-GR, 1	PRE-GR, 5	SQ-MP-TC, 14	PRE-GR, 5	CE-PRE-GR, 30	PRE-GR, 5	CE-PRE-GR, 30
		B	BC-GR, 1	BS-GR, 11	BS-GR, 16	PRE-GR, 15 (2)	PRE-GR, 13 (2)	SQ-MP-TC, 17	PRE-GR, 13	CE-PRE-GR, 36	PRE-GR, 13	CE-PRE-GR, 36
	6	A		BS-GR, 1		BS-GR, 2	PRE-GR, 6	CE-MP-GR, 34	BS-GR, 3		BS-GR, 3	
		B		BS-GR, 9		PRE-GR, 15 (4)	PRE-TC (3)	CE-MP-GR, 42	BS-GR, 13		BS-GR, 13	
	7	A		BS-GR, 7		PRE-GR, 17 (4)	PRE-TC (5)		PRE-GR, 7		PRE-GR, 7	
		B		BS-GR, 15		PRE-GR, 19 (4)	BS-GR, 15		PRE-GR, 10		PRE-GR, 10	
	8	A		BS-GR, 7		PRE-GR, 2 (4)	BS-GR, 5					
		B		BS-GR, 15		PRE-TC (3)	PRE-GR, 15 (2)					
	9	A		BS-GR, 2		PRE-GR, 1	BS-GR, 5					
		B		BS-GR, 11		PRE-TC, 2 (2)	PRE-TC (5)					
	10	A		BS-GR, 2		PRE-TC, 1	PRE-GR, 6					
		B		BS-GR, 11		BS-GR, 9	BS-GR, 15					

Footnotes on next page

Footnotes to Table 9

(1) This firing exercise requires the gunner to simulate zeroing the main gun. Zeroing was excluded from our analysis of gunnery objectives.

(2) This firing exercise requires the use of white light beyond 1600 meters. The maximum effective range of white light is approximately 1600 meters.

(3) This exercise requires the TC to range on a target using the rangefinder with metascope. The rangefinder with metascope can only be used effectively against targets emitting an IR light source.

(4) This firing exercise requires the GNR to fire HEP ammunition against a tank or tank-like target. HEP ammunition is not recommended for use against tank or tank-like targets.

(5) This firing exercise requires the TC to range on a moving target and simultaneously to track it. This task seems impossible, as tracking and ranging both are right-hand operations.

(6) This firing exercise requires the use of infrared light (IR) beyond 1100 meters. The maximum effective range capability of IR is approximately 1100 meters.

The parenthetical entries are explained in the footnotes to Table 9. Footnotes 2 through 6 refer to apparent errors in the exercises. Footnote 3, for example, refers to exercises that have the TC using the metescope against targets that do not emit IR light. And Footnote 5 refers to exercises in which the TC must range on a moving target and simultaneously track it -- a seemingly impossible task, since tracking and ranging are both right-hand operations. Of the 137 gunnery exercises, 19 were found to contain errors of the kind noted above. We understand that these are being corrected in forthcoming revisions of TC 17-12-5.

Training Objectives

Each of the gunnery exercises in TC 17-12-5 that pertained to the M60A1AOS tank was reviewed, and was written in two forms:

1. A narrative form that included task, conditions, and standards statements.

2. An abbreviated form similar to the one used for presenting the job objectives in Tables 1 through 7.

Method

An example of a training exercise (Exercise 3A from Gunnery Table I) from TC 17-12-5 is:

UNIT ____ CREW ____ TANK CREW ____ GUNNER ____ LOADER ____ DRIVER ____

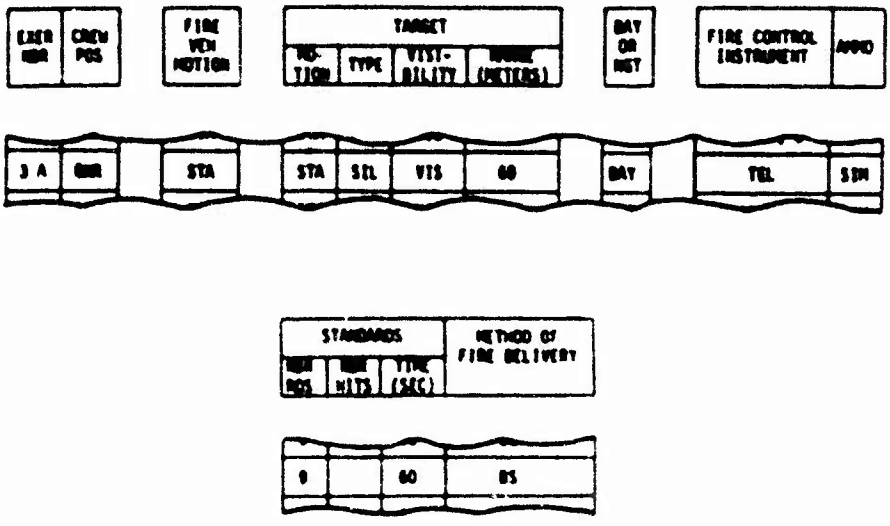
EXERCISE	NO. RDS	REQUIREMENT	POSSIBLE SCORE	PRACTICE SCORE	RECORD SCORE
3 MANIPULATION (Secondary Sight)	9	Each hit	10	____	____
		No points awarded for hits after 1 minute time limit			
		Total Possible	90	____	____

This exercise was translated into the following narrative form:

> "Given (a) a stationary M60A1AOS tank with a main gun simulation device, (b) an operational gunner's telescope, and (c) a stationary silhouette target (flank view of Soviet tanks) that is visible at 60 meters during the day; the gunner will hit __ out of 9 targets within 60 seconds, using no more than 9 rounds."[1]

[1] In cases where the exercises did not include a standard or part of a standard, blank spaces were left in the corresponding narrative and tabular presentation.

In the abbreviated form, Exercise 3A, Table I was recorded as follows:



Transformations from training exercise to narrative to tabular form were done for each training exercise, as described and illustrated above.

Results

The training objectives resulting from the translation of the gunnery exercises are presented in abbreviated form in Tables 10 through 17. Narratives of the objectives are available from ARI (Kraemer, et al., 1975).

The training objectives presented in Tables 10 through 17 parallel the organization of the eight gunnery firing tables: our Table 10 summarizes Gunnery Table I, our Table 11 summarizes Gunnery Table II, and so forth through our Table 17, which summarizes Gunnery Table VIII.

TABLE 10

TRAINING OBJECTIVES: SUMMARY OF EXERCISES IN GUNNERY

TABLE I (ZERO AND MANIPULATION) OF TC 17-12-5, OCTOBER, 1974

EXER NBR	CREW POS	FIRE VEH MOTION	TARGET				DAY OR NGT	FIRE CONTROL INSTRUMENT	AMMO	STANDARDS			METHOD OF FIRE DELIVERY
			MOTION	TYPE	VISIBILITY	RANGE (METERS)				RBR RDS	RBR HITS	TIME (SEC)	
1 A	GNR	STA	STA	ZERO[1]	VIS	60	DAY	GNR/PER, D	SIM[2]	4	1		BS
2 A	GNR	STA	STA	SIL[3]	VIS	60	DAY	GNR/PER, D	SIM	9		60	BS
3 A	GNR	STA	STA	SIL	VIS	60	DAY	TEL	SIM	9		60	BS
2 B	GNR	STA	STA	SIL	VAL	60	NGT	GNR/PER, IR	SIM	9		60	BS
3 B	GNR	STA	STA	SIL	VAL	60	NGT	TEL(ML)	SIM	9		60	BS
4 B	GNR	STA	STA	SIL	NVS	60	NGT	AUX	SIM	1	1		RC
5 B	GNR	STA	STA	SIL	VAL	60	NGT	AUX, GNR/PER,D	SIM	1	1		RCDF

[1] Silhouette type-E target with 4" zeroing circle

[2] Subcaliber device such as the laser, 7.62 frangible, and cal. 22 in bore device.

[3] Silhouette type-E target with an array of 3" x 4" shapes and figures.

TABLE II

TRAINING OBJECTIVES: SUMMARY OF EXERCISES IN GUNNERY TABLE II (FUNDAMENTALS OF FIRE ADJUSTMENT) OF TC 17-12-5, OCTOBER, 1974

EXER NBR	CREW POS	FIRE DEM MOTION	TARGET				DAY OR NGT	FIRE CONTROL INSTRUMENT	AMMO	STANDARDS			METHOD OF FIRE DELIVERY/ ADJUSTMENT
			DEMO-TION	TYPE	VIST-BILITY	RANGE (METERS)				ROUNDS	HITS	TIME (SEC)	
1 A	GNR	STA	STA	SIL	VIS	60	DAY	GNR/PER. D	SIM	2	1		BS/BOT
2 A	GNR	STA	STA	SIL	VIS	60	DAY	GNR/PER. D	SIM	2	1		BS/TF
3 A	GNR	STA	STA	SIL	VIS	60	DAY	GNR/PER. D	SIM	2	1		BS/BOT
4 A	GNR	STA	STA	SIL	VIS	60	DAY	TEL	SIM	2	1		BS/BOT
5 A	GNR	STA	STA	SIL	VIS	60	DAY	TEL	SIM	2	1		BS/TF
6 A	GNR	STA	STA	SIL	VIS	60	DAY	GNR/PER. D	SIM	2	1		BS/BOT
7 A	GNR	STA	STA	SIL	VIS	60	DAY	GNR/PER. D	SIM	2	1		BS/TF
8 A	GNR	STA	STA	SIL	VIS	60	DAY	GNR/PER. D	SIM	2	1		BS/BOT
9 A	GNR	STA	STA	SIL	VIS	60	DAY	TEL	SIM	2	1		BS/BOT
10 A	GNR	STA	STA	SIL	VIS	60	DAY	TEL	SIM	2	1		BS/TF
1 B	GNR	STA	STA	SIL	VAL	60	NGT	GNR/PER. D(ML)	SIM	2	1		BS/BOT
2 B	GNR	STA	STA	SIL	VAL	60	NGT	GNR/PER. D(ML)	SIM	2	1		BS/TF
3 B	GNR	STA	STA	SIL	VAL	60	NGT	GNR/PER. IR	SIM	2	1		BS /BOT
4 B	GNR	STA	STA	SIL	VAL	60	NGT	TEL (ML)	SIM	2	1		BS/BOT
5 B	GNR	STA	STA	SIL	VAL	60	NGT	TEL (ML)	SIM	2	1		BS/TF
6 B	GNR	STA	STA	SIL	VAL	60	NGT	GNR/PER. D(ML)	SIM	2	1		BS/BOT
7 B	GNR	STA	STA	SIL	VAL	60	NGT	GNR/PER. IR	SIM	2	1		BS/TF
8 B	GNR	STA	STA	SIL	VAL	60	NGT	GNR/PER. IR	SIM	2	1		BS/BOT
9 B	GNR	STA	STA	SIL	VAL	60	NGT	TEL (ML)	SIM	2	1		BS/BOT
10 B	GNR	STA	STA	SIL	VAL	60	NGT	TEL (ML)	SIM	2	1		BS/TF

TABLE 12

TRAINING OBJECTIVES: SUMMARY OF EXERCISES IN GUNNERY TABLE III (TRACKING AND ADJUSTMENT TECHNIQUES) OF TC 17-12-5, OCTOBER, 1974

EXER NBR	CREW POS	FIRE VEH MOTION	TARGET				DAY OR NGT	FIRE CONTROL INSTRUMENT	AMMO	STANDARDS			METHOD OF FIRE DELIVERY/ ADJUSTMENT
			MOTION	TYPE	VISIBILITY	RANGE (METERS)				NBR RDS	NBR HITS	TIME (SEC)	
1 A	GNR	STA	MOV	SIL	VIS	60	DAY	GNR/PER, D	SIM	2	1		BS/BOT
2 A	GNR	STA	MOV	SIL	VIS	60	DAY	TEL	SIM	2	1		BS/BOT
3 A	GNR	STA	MOV	SIL	VIS	60	DAY	GNR/PER, D	SIM	2	1		BS/TF
4 A	GNR	STA	MOV	SIL	VIS	60	DAY	TEL	SIM	2	1		BS/TF
5 A	GNR	STA	MOV	SIL	VIS	60	DAY	GNR/PER, D	SIM	2	1		BS/BOT
1 B	GNR	STA	MOV	SIL	VAL	60	NGT	GNR/PER, D(WL)	SIM	2	1		BS/BOT
2 B	GNR	STA	MOV	SIL	VAL	60	NGT	TEL (WL)	SIM	2	1		BS/BOT
3 B	GNR	STA	MOV	SIL	VAL	60	NGT	GNR/PER, D(WL)	SIM	2	1		BS/TF
4 B	GNR	STA	MOV	SIL	VAL	60	NGT	TEL (WL)	SIM	2	1		BS/TF
5 B	GNR	STA	MOV	SIL	VAL	60	NGT	GNR/PER, IR	SIM	2	1		BS/BOT

TABLE 13

TRAINING OBJECTIVES: SUMMARY OF EXERCISES IN GUNNERY TABLE IV (TANK FIRE ADJUSTMENT TECHNIQUES) OF TC 17-12-5, OCTOBER, 1974

EXER NBR	CREW POS	FIRE VEH MOTION	TARGET				DAY OR NGT	FIRE CONTROL INSTRUMENT	AMMO	STANDARDS			METHOD OF FIRE DELIVERY
			MOTION	TYPE	VISIBILITY	RANGE (METERS)				RDS	HITS	TIME (SEC)	
1 A	GNR	STA	STA	TK	VIS	600-1600	DAY	GNR/PER, D	SABOT	2	1	15	BS
2 A	GNR	STA	STA	TK	VIS	1500-3000	DAY	GNR/PER, D	SABOT	2	1	20	PRE
3 A	GNR	STA	STA	TK	VIS	1500-2000	DAY	TEL	SABOT	2	1	20	PRE
4 A	GNR	STA	STA	TK	VIS	600-1100	DAY	GNR/PER, D	HEAT	2	1	15	BS
5 A	GNR	STA	STA	TK	VIS	1500-2000	DAY	GNR/PER, D	HEAT	2	1	20	PRE
6 A	GNR	STA	STA	TK	VIS	900-1300	DAY	TEL	HEAT	2	1	15	BS
7 A	GNR	STA	STA	AT	VIS	1000-1200	DAY	GNR/PER, D	HEP	2	1	20	PRE
8 A	GNR	STA	STA	AT	VIS	1200-1400	DAY	TEL	HEP	2	1	20	PRE
9 A	GNR	STA	STA	TK	VIS	1000-1800	DAY	GNR/PER, D	SABOT	2	1	20	PRE
10 A	TC	STA	STA	TK	VIS	1500	DAY	RFDR/D	SABOT	2	1	20	PRE
1 B	GNR	STA	STA	TK	VAL	1000-1500	NGT	GNR/PER, D(ML)	SABOT	2	1	25	PRE
2 B	GNR	STA	STA	TK	VAL	1500-2500	NGT	GNR/PER, D(ML)	SABOT	2	1	25	PRE
3 B	GNR	STA	STA	TK	VAL	800-1000	NGT	GNR/PER, IR	SABOT	2	1	25	PRE
4 B	GNR	STA	STA	TK	VAL	800-1000	NGT	GNR/PER, IR	SABOT	2	1	25	PRE
5 B	GNR	STA	STA	TK	VAL	1400-1800	NGT	TEL (ML)	SABOT	2	1	25	PRE
6 B	GNR	STA	STA	AT	VAL	1400-1600	NGT	TEL (ML)	HEP	2	1	25	PRE
7 B	GNR	STA	STA	AT	VAL	1000-1400	NGT	GNR/PER, D(ML)	HEP	2	1	25	PRE
8 B	GNR	STA	STA	AT	VAL	800-1000	NGT	GNR/PER, IR	HEP	2	1	25	PRE
9 B	TC	STA	STA	TK	VAL	1500-2000	NGT	RFDR, D(ML)	SABOT	2	1	25	PRE
10 B	GNR	STA	STA	TK	VAL	600-1600	NGT	GNR/PER,D(SML)	SABOT	2	1	20	BS

TABLE 14

TRAINING OBJECTIVES: SUMMARY OF EXERCISES IN GUNNERY TABLE V (LEADING, TRACKING, ENGAGING, AND ADJUSTING FIRE ON MOVING TARGETS WITH THE MAIN GUN) OF TC 17-12-5, OCTOBER, 1974

EXER NBR	CREW POS	FIRE VEH MOTION	TARGET				DAY OR NGT	FIRE CONTROL INSTRUMENT	AMMO	STANDARDS			METHOD OF FIRE DELIVERY
			MOTION	TYPE	VISIBILITY	RANGE (METERS)				RDS	HITS	TIME (SEC)	
1 A	GNR	STA	MOV	TL	VIS	1000-1600	DAY	GNR/PER, D	SABOT	2	1	20	PRE
2 A	GNR	STA	MOV	TL	VIS	1600-2400	DAY	GNR/PER, D	SABOT	2	1	20	PRE
3 A	GNR	STA	MOV	TL	VIS	1400-2000	DAY	TEL	SABOT	2	1	20	PRE
4 A	GNR	STA	MOV	TL	VIS	600-1100	DAY	GNR/PER, D	HEAT	2	1	15	BS
5 A	GNR	STA	MOV	TL	VIS	1700-2000	DAY	GNR/PER, D	HEAT	2	1	20	PRE
6 A	GNR	STA	MOV	TL	VIS	1400-1800	DAY	TEL	HEAT	2	1	20	PRE
7 A	TC	STA	MOV	TL	VIS	1000-1800	DAY	RFDR, D	SABOT	2	1	20	PRE
8 A	GNR	STA	MOV	TL	VIS	600-1200	DAY	GNR/PER, D	SABOT	2	1	15	BS
9 A	GNR	STA	MOV	TL	VIS	1200-1600	DAY	GNR/PER, D	SABOT	2	1	15	BS
10 A	GNR	STA	MOV	TL	VIS	800-1000	DAY	TEL	SABOT	2	1	20	PRE
1 B	GNR	STA	MOV	TL	VAL	800-1400	NGT	GNR/PER, D(ML)	SABOT	2	1	25	PRE
2 B	GNR	STA	MOV	TL	VAL	1200-1600	NGT	GNR/PER, D(ML)	SABOT	2	1	20	BS
3 B	GNR	STA	MOV	TL	VAL	800-1000	NGT	GNR/PER, IA	SABOT	2	1	25	PRE
4 B	GNR	STA	MOV	TL	VAL	1400-1800	NGT	TEL (ML)	SABOT	2	1	25	PRE
5 B	GNR	STA	MOV	TL	VAL	1800-2000	NGT	GNR/PER, D(ML)	HEAT	2	1	25	PRE
6 B	GNR	STA	MOV	TL	VAL	800-1200	NGT	GNR/PER, IA	HEAT	2	1	25	PRE
7 B	GNR	STA	MOV	TL	VAL	600-1000	NGT	GNR/PER, IA	HEAT	2	1	25	BS
8 B	GNR	STA	MOV	TL	VAL	800-2200	NGT	TEL (ML)	HEAT	2	1	25	PRE
9 B	TC	STA	MOV	TL	VAL	1600-2000	NGT	RFDR, D(ML)	SABOT	2	1	25	PRE
10 B	GNR	STA	MOV	TL	VAL	800-1200	NGT	GNR/PER,D(SML)	SABOT	2	1	20	BS

TABLE 15

TRAINING OBJECTIVES: SUMMARY OF EXERCISES IN GUNNERY TABLE VI (CREW COORDINATION AND ABILITY TO ENGAGE MOVING AND STATIONARY TARGETS WITH MACHINEGUNS) OF TC 17-12-5, OCTOBER, 1974

FIER NBR	CREW POS	FIRE VEH MOTION	TARGET				DAY OR NGT	FIRE CONTROL INSTRUMENT	AMMO	STANDARDS			METHOD OF FIRE DELIVERY
			MOTION	TYPE	VISIBILITY	RANGE (METERS)				NBR RDS	NBR HITS	TIME (SEC)	
1 A	TC	STA	STA	LAV	VIS	1000-1400	DAY	TC/PER, D	CAL50	50	1		NP
2 A	GNR	STA	MOV	LAV	VIS	600-800	DAY	GNR/PER, D	COAX	60	1		PRE
3 A	GNR	MOV	STA	TRP	VIS	600-800	DAY	INF	COAX	150			PRE
4 A	GNR	MOV	STA	TRP	VIS	200-400	DAY	INF	COAX	75			NP
5 A	TC	MOV	STA	TRP	VIS	1000-1400	DAY	TC/PER, D	CAL50	50			NP
6 A	GNR	MOV	STA	TRP	VIS	600-800	DAY	INF	COAX	150			PRE
1 B	TC	STA	STA	LAV	VAL	1000-1400	NGT	TC/PER, IR	CAL50	50	1		NP
2 B	GNR	STA	MOV	LAV	VAL	600-800	NGT	GNR/PER, D(WL)	COAX	60	1		PRE
3 B	GNR	MOV	STA	TRP	VAL	600-800	NGT	INF (WL)	COAX	150			PRE
4 B	GNR	MOV	STA	TRP	VAL	200-400	NGT	GNR/PER, IR	COAX	75			NP
5 B	TC	MOV	STA	TRP	VAL	1000-1400	NGT	TC/PER, D(WL)	CAL50	50			NP
6 B	GNR	MOV	STA	TRP	VAL	600-800	NGT	INF (WL)	COAX	150			PRE

TABLE 16

TRAINING OBJECTIVES - SUMMARY OF EXERCISES IN GUNNERY TABLE VII (FIRING MOVING AND STATIONARY TARGETS WITH ALL TANK MOUNTED WEAPONS, PREPARING FOR TABLE VIII) OF TC 17-12-5, OCTOBER, 1974

CREW MBR	CREW POS	FIRE PER MOTION	TARGET				DAY OR NGT	FIRE CONTROL INSTRUMENT	AMMO	STANDARDS			METHOD OF FIRE DELIVERY
			MOTION	TYPE	RANGE (METERS)					CREW POS	HITS	TIME (SEC)	
1 A	GNR	STA	STA	TK	DIS	1200-1600	DAY	GNR/PER, D	SABOT	2	1	15	BS
2 A	GNR	STA	STA	TK	DIS	1200-1600	DAY	GNR/PER, D	SABOT	2	1	15	BS
3 A	GNR	STA	STA	TK	DIS	1600-2400	DAY	GNR/PER, D	SABOT	2	1	20	PRE
4 A	GNR	STA	STA	TK	DIS	800-1200	DAY	GNR/PER, D	SABOT	2	1	15	BS
5 A	GNR	STA	MOV	TK	DIS	1800-2000	DAY	GNR/PER, D	HEAT	2	1	20	PRE
6 A	GNR	STA	STA	TK	DIS	800-1200	DAY	GNR/PER, D	HEAT	2	1	15	BS
7 A	GNR	STA	STA	AT	DIS	1200-1400	DAY	TEL	HEP	2	1	20	PRE
1 B	GNR	STA	STA	TK	NAL	1200-1400	NGT	GNR/PER, D(NL)	SABOT	2	1	20	BS
2 B	GNR	STA	STA	TK	NAL	1200-1600	NGT	GNR/PER, D(NL)	SABOT	2	1	20	BS
3 B	GNR	STA	STA	TK	NAL	600-2400	NGT	GNR/PER, D(NL)	SABOT	2	1	25	PRE
4 B	GNR	STA	STA	TK	NAL	800-1200	NGT	GNR/PER, D	SABOT	2	1	20	BS
5 B	GNR	STA	MOV	TK	NAL	1800-2000	NGT	GNR/PER, D(NL)	HEAT	2	1	25	PRE
6 B	GNR	STA	STA	TK	NAL	800-1200	NGT	GNR/PER, D	HEAT	2	1	20	BS
7 B	GNR	STA	STA	AT	NAL	1200-1400	NGT	TEL (NL)	HEP	2	1	25	PRE
1 A	TC	STA	STA	LAV	DIS	1000-1600	DAY	TC/PER, D	CAL 50	50	1		HP
2 A	GNR	MOV	STA	TRP	DIS		DAY	INF	COAX	150			HP
3 A	TC	MOV	STA	TRP	DIS	200-400	DAY	TC/PER, D	CAL 50	50			HP
4 A	GNR	STA	MOV	LAV	DIS	800-800	DAY	GNR/PER, D	COAX	60	1		PRE
5 A	GNR	MOV	STA	TRP	DIS	600-800	DAY	INF	COAX	100			PRE
1 B	TC	STA	STA	LAV	NAL	1000-1400	NGT	TC/PER, D	CAL 50	50	1		HP
2 B	GNR	MOV	STA	TRP	NAL		NGT	GNR/PER, D	COAX	150			HP
3 B	TC	MOV	STA	TRP	NAL	200-400	NGT	TC/PER, D(NL)	CAL 50	50			HP
4 B	GNR	STA	MOV	LAV	NAL	800-800	NGT	GNR/PER, D(NL)	COAX	80	1		PRE
5 B	GNR	MOV	STA	TRP	NAL	800-800	NGT	INF (NL)	COAX	100			PRE

TABLE 17

TRAINING OBJECTIVES: SUMMARY OF EXERCISES IN GUNNERY

TABLE VIII (QUALIFICATION) OF TC 17-12-5, OCTOBER, 1974

EMER ADD	CREW POS	FIRE VEH MOVTION	TARGET				DAY OR NIGHT	FIRE CONTROL INSTRUMENT	AMMO	STANDARDS			METHOD OF FIRE DELIVERY
			NO. TGTS	TYPE	VIST-BILITY	RANGE (METERS)				RDS OBTN	HITS	TIME (SEC)	
1 A	GNR	STA	STA	TK	VIS	1200-1600	DAY	GNR/PER. D	SABOT	3	1	15	DS
2 A	GNR	STA	STA	TK	VIS	1200-1600	DAY	GNR/PER. D	SABOT	3	1	15	DS
3 A	GNR	STA	STA	TK	VIS	1600-2400	DAY	GNR/PER. D	SABOT	3	1	20	PRE
4 A	GNR	STA	STA	TK	VIS	800-1100	DAY	GNR/PER. D	SABOT	3	1	15	DS
5 A	GNR	MOV	MOV	TK	VIS	1600-2000	DAY	GNR/PER. D	HEAT	3	1	20	PRE
6 A	GNR	STA	STA	TK	VIS	800-1600	DAY	GNR/PER. D	HEAT	3	1	15	DS
7 A	GNR	STA	STA	AT	VIS	1200-1300	DAY	TEL	HEP	3	1	20	PRE
1 B	GNR	STA	STA	TK	NVL	1200-1600	NGT	GNR/PER. IR	SABOT	3	1	20	DS
2 B	GNR	STA	STA	TK	NVL	1200-1600	NGT	GNR/PER.D(NVL)	SABOT	3	1	20	DS
3 B	GNR	STA	STA	TK	NVL	1600-2400	NGT	GNR/PER. D(NVL)	SABOT	3	1	25	PRE
4 B	GNR	STA	STA	TK	NVL	800-1600	NGT	GNR/PER. D(NVL)	SABOT	3	1	20	DS
5 B	GNR	STA	MOV	TK	NVL	1000-2000	NGT	GNR/PER. D(NVL)	HEAT	3	1	25	PRE
6 B	GNR	STA	STA	TK	NVL	800-1600	NGT	GNR/PER. D(NVL)	HEAT	3	1	20	DS
7 B	GNR	STA	STA	AT	NVL	1200-1400	NGT	TEL (NVL)	HEP	3	1	25	PRE
1 A	TC	STA	STA	LAV	VIS	1000-1400	DAY	TC/PER. D	CAL50	50	1		HP
2 A	GNR	MOV	STA	TRP	VIS		DAY	INF	COAX	150			HP
3 A	TC	MOV	STA	TRP	VIS	200-600	DAY	TC/PER. D	CAL50	50			HP
4 A	GNR	STA	MOV	LAV	VIS	600-800	DAY	GNR/PER. D	COAX	60	1		PRE
5 A	GNR	MOV	STA	TRP	VIS	600-800	DAY	INF	COAX	100			PRE
1 B	TC	STA	STA	LAV	NVL	1000-1400	NGT	TC/PER. IR	CAL50	50	1		HP
2 B	GNR	MOV	STA	TRP	NVL		NGT	GNR/PER. IR	COAX	150			HP
3 B	TC	MOV	STA	TRP	NVL	600-800	NGT	TC/PER. IR	CAL50	50			HP
4 B	GNR	STA	MOV	LAV	NVL	600-800	NGT	GNR/PER.D(NVL)	COAX	60	1		PRE
5 B	GNR	MOV	STA	TRP	NVL	600-800	NGT	INF (NVL)	COAX	100			PRE

Consider the second row entry in Table 10:

1. The EXER NBR indicates that the training objective corresponds to Exercise 2A (from Gunnery Table I).

2. The GNR entry under CREW POS indicates that the firing is to be done from the gunner's station.

3. Firing vehicle motion is stationary (STA).

4. The target is a stationary tank silhouette (SIL) visible without artificial light (VIS) at 60 meters.

5. The exercise is to be practiced under daylight (DAY) conditions.

6. The gunner's day periscope (GNR/PER, D) is to be used.

7. SIM under AMMO indicates that simulated firing is used in the exercise.

8. The entries under STANDARDS indicate that 9 rounds are to be fired within 60 seconds, with the number of hits unspecified.

9. BS under METHOD OF FIRE DELIVERY indicates that the battlesight method of fire delivery is used.

Using the information given above, the training objective corresponding to Exercise 2A of Table I can be written as:

> "Given (a) a stationary M60A1AOS tank with a main gun simulation device, (b) an operational gunner's periscope, and (c) a stationary silhouette target that is visible at 60 meters (simulated) without artificial light during the day; the gunner will score __ hits within 60 seconds, using no more than 9 rounds."

Discussion

The conditions and activity parts of the training objectives are subject to the same comments as were made about the job objectives; namely, that some important conditions are not included in the objec-

tives, and that "hit targets" is too general a statement of the gunnery job. These comments can be dismissed on the grounds presented earlier.

One of the most notable aspects of the training objectives in Tables 10 through 17 is the number of blank spaces in the STANDARDS columns. The inclination to criticize the standards on the basis of incompleteness, however, must be balanced against the fact that the incompleteness is intentional. The designers of the gunnery tables have built flexibility into Tables I through VII, to permit unit commanders to decide when their units are ready to progress from one table to the next. The need for flexibility usually is justified on the grounds that different units may have different training needs, and that training resources and demands fluctuate over time.

Maintaining flexibility in the standards for Tables I through VII may be reasonable, inasmuch as the standards for Table VIII are rigid (at least for main gun engagements; no closing times are given for the machineguns). The designers of the proposed tables are, in essence, telling unit commanders, "It's up to you to decide <u>when</u> your people are ready to progress and qualify, but you will have nothing to say about <u>whether</u> they are qualified." Flexibility in standards presents problems though. The main problem is that, without rigid standards, one never knows "where crews are" with respect to proficiency or readiness. Statements such as, "All crews with <u>X</u> weeks of training have achieved Table VI standards," are meaningless if the "standards" for Table VI are flexible. Any comparison among crews that uses flexible standards will be unsatisfactory for the same reasons that measuring length with a rubber ruler is unsatisfactory.

It is also difficult to see how, with flexible standards, unit commanders can decide when a unit is ready to progress from one table to another. Such decisions would be easier to make (and justify) if the "standards" for Tables I through VII were more complete.

The issue of where standards come from was discussed with respect to job objectives, and applies equally to the training objectives. The best standards are those that reflect the need for being more proficient than the enemy. The worst are those that are based on expert opinion.

The standards for Table VIII are complete, and therefore do provide a basis for proficiency assessment. And scoring for Table VIII reflects the growing concern with economy in tank gunnery: points are awarded for speed, accuracy, and conserving ammunition. But the rationale is not clear for allocating three rounds for each main gun qualification exercise when in training only two rounds are allocated. The emphasis on conserving ammunition is appropriate and should perhaps be increased, inasmuch as firing the proposed tables requires considerably more ammunition[1] than did firing their predecessors.

Numerical Summaries

After transforming the gunnery exercises into training objectives, a numerical summary was prepared, showing how many training objectives

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[1]The ammunition requirements presented in FM 17-12 are based on three crew members firing Tables IV and V. The requirements in TC 17-12-5 (October 1974) are based on only one crew member firing Tables IV and V. Correcting the data so that only one crew member fires the FM 17-12 tables, one finds that 84 rounds of 105mm ammunition are required to fire the old tables, as compared to 150 rounds for the tables in TC 17-12-5.

pertained to each weapon, fire delivery method, and firing table. This summary is presented in Table 18.

The total number of objectives (129) in Table 18 is eight less than the total number of exercises in Gunnery Tables I through VIII, for reasons cited in the footnote of Table 18. Ninety-seven of the exercises (about three-quarters of the total) are for main gun training; and of the 97, 60 are battlesight exercises. The heavy emphasis on main gun training, and especially main gun battlesight training, seems appropriate in light of assumptions about mid-intensity European conflicts. A question naturally arises, though, about the balance of exercises across weapons and methods of fire delivery in the tables. Only two of the main gun exercises provide range card practice, and no exercises are provided for range card or range card lay to direct fire with the coax. The assumption here may be that whatever is learned during range card practice in Exercises 4B and 5B of Table I will generalize to the coax. Since the range card practice is given early in training, and in only two exercises though, long-term retention of range card skills probably is not good -- an issue that is not easily resolved, since there are no range card exercises in Table VIII. Perhaps the reasons for the exclusion is economy. Range card firing on area targets with the main gun would require five rounds. Consideration should be given though to including a less expensive range card engagement in Table VIII -- a coax engagement, for example.

Some of the skills practiced in one gunnery table are repeated in other tables. The range may change from one exercise to another, for example, but the manipulations required of the gunner do not. For this

TABLE 18

NUMBERS OF TRAINING OBJECTIVES BY
WEAPON, FIRE DELIVERY METHOD, AND FIRING TABLE[1]

WEAPON	FIRING TABLE	I	II	III	IV	V	VI	VII	VIII	TOTALS
MAIN GUN	Battlesight	4	20	10	4	6	0	8	8	60
	Precision	0	0	0	13	10	0	6	6	35
	Range Card	1	0	0	0	0	0	0	0	1
	Range Card Lay to Direct Fire	1	0	0	0	0	0	0	0	1
	MAIN GUN TOTALS	6	20	10	17	16	0	14	14	97
COAXIAL MACHINEGUN	Non-precision	0	0	0	0	0	6	2	2	10
	Precision	0	0	0	0	0	2	4	4	10
	Range Card	0	0	0	0	0	0	0	0	0
	Range Card Lay to Direct Fire	0	0	0	0	0	0	0	0	0
	COAX TOTALS	0	0	0	0	0	8	6	6	20
CAL .50 MACHINEGUN	Non-precision	0	0	0	0	0	4	4	4	12
	TOTALS	6	20	10	17	16	12	24	24	129

[1] Eight exercises were omitted from the totals in this table:

- Exercise 1A, Table I, which is a prerequisite to other exercises, and could not be classified by method of fire delivery.
- Exercises 3B, 4B, and 8B of Table IV; and Exercises 3B and 4B of Table V, which require use of the metascope against targets that do not emit IR light.
- Exercises 7A and 9B of Table V, which require simultaneous tracking and ranging by the TC.

reason, many of the training objectives written from the exercises were virtually identical. In order to examine the extent of redundancy in the gunnery tables, we counted for each table the number of exercises that required skills that had not been practiced in any preceding table. The results of this count are presented in Table 1[illegible]. Of the 97 main gun exercises, 47 involve skills that are required in no other exercises; that is, 50 of the exercises require practicing skills that were practiced in an earlier firing table. Of the 20 coax exercises, nine were sufficiently different from one another to qualify as "different" training objectives. Five of the 12 caliber .50 exercises so qualify. Of the 129 training objectives, a total of 61 are unique.

Part of the reason for the redundancy in the firing tables is that some of the exercises involve part-task practice -- in which case it makes sense for more than one exercise to address one objective. But the possibility that some objectives are being overtaught should be considered: Do trainees really need to perform 60 main gun battlesight exercises in order to master the 31 unique objectives? If not, then perhaps some resources could be shifted to "beef up" parts of the tables where undertraining seems likely (e.g., range card firing).

Conclusion

Some errors in the gunnery tables were noted. These can be (and apparently are being) easily corrected.

A cursory review of the firing tables reveals some violations of the tenets of instructional technology. But increased familiarity with the tables leads to the conclusion that the "violations" may, in fact,

TABLE 19

NUMBERS OF DIFFERENT TRAINING OBJECTIVES
BY WEAPON, FIRE DELIVERY METHOD, AND FIRING TABLE

WEAPON	FIRING TABLE	I	II	III	IV	V	VI	VII	VIII	TOTALS
MAIN GUN	Battlesight	4	10	9	3	3	0	2	0	31
	Precision	0	0	0	9	4	0	1	0	14
	Range Card	1	0	0	0	0	0	0	0	1
	Range Card Lay to Direct Fire	1	0	0	0	0	0	0	0	1
	MAIN GUN TOTALS	6	10	9	12	7	0	3	0	47
COAXIAL MACHINEGUN	Non-precision	0	0	0	0	0	4	0	0	4
	Precision	0	0	0	0	0	2	3	0	5
	Range Card	0	0	0	0	0	0	0	0	0
	Range Card Lay to Direct Fire	0	0	0	0	0	0	0	0	0
	COAX TOTALS	0	0	0	0	0	6	3	0	9
CAL .50 MACHINEGUN	Non-precision	0	0	0	0	0	4	0	1	5
	TOTALS	6	10	9	12	7	10	6	1	61

be concessions to practical constraints. Standards for Tables I through VII, for example, are deliberately incomplete, to provide flexibility for unit commanders. But the need for flexibility must be weighed against the need for "knowing where we are" with respect to gunnery proficiency and readiness. Consideration also should be given to relying less on expert opinion for standard-setting, and more on information about enemy capability.

The heavy emphasis of the tables on some methods of fire delivery (battlesight and precision) to the near-exclusion of others (range card and range card lay to direct fire) raises questions not only about the rationales for the imbalance, but also about whether the little-practiced exercises are being learned at all. And the large discrepancy between the total numbers of training objectives and unique objectives suggests that some overtraining may be ongoing.

Finally, the increasing emphasis on economy in gunnery training, coupled with limitations on training resources, suggests that examinations are in order, of potentially less expensive alternatives for accomplishing gunnery training objectives.

JOB OBJECTIVES AND TRAINING OBJECTIVES COMPARED

Ideally, evaluations of training programs should take one or both of two forms:

1. Empirical studies of the relevance of training, to establish the extent to which skills and knowledge acquired in training are related to performance on the job.

2. Empirical studies of the effectiveness of training: given that training objectives are highly relevant to performance on the job, to what extent is the program meeting its objectives?

The stringent empirical requirements posed by both kinds of studies are a mixed blessing. Empirical studies of training relevance and effectiveness, if competently designed, conducted, and interpreted, can yield iron-clad cases for training revisions. But the high costs, administrative problems, and interpretive difficulties associated with the conduct of such studies demand reliance on less costly but admittedly less convincing means for training evaluation -- "soft" evaluations such as those that are possible using the job objectives and training objectives presented earlier in this report. Confidence in the results of such evaluations rests on the validity of several assumptions:

1. That our job objectives are reasonably comprehensive; that is, the job objectives represent well the full range of ways that crews can neutralize targets using the weaponry available on the M60A1AOS.

2. That the probability of success in combat increases with increases in crews' ability to neutralize targets using all of the means provided by M60A1AOS firepower and weaponry.

3. That our translations of gunnery training content into the gunnery training objectives presented earlier are reasonably accurate representations of what is being covered in gunnery training.

4. That whatever is being learned by gunnery trainees is less than what is being addressed by gunnery training.

Our comparisons of gunnery job and training objectives are presented with reservations: Without empirical evaluations of the relevance and effectiveness of gunnery training, no unequivocal conclusions can be drawn. And without such studies, we can neither confirm or refute the following claims (1) that gunnery training as presently conducted yields maximum effectiveness at least cost, and (2) that if "the flag dropped" tomorrow we would find that our tank crews were indeed capable of neutralizing targets using the entire gamut of weaponry and firepower provided by the M60A1AOS. These are open questions that can never be fully resolved without empirical studies of the kind mentioned above. We contend, however, that even without such studies the case for revised gunnery training is easily made.

Comparisons

One means for comparing the job objectives and the training objectives is to compare their total numbers. There are 225 job objectives and only 129 training objectives, so something seems to be missing from training. Further, if a single job objective is addressed by more than one training objective, then the number of job objectives left "uncovered" by training seems considerable.[1] Notice though, that total numbers of

[1] Readers interested in exactly which job objectives are and are not covered by training are referred to Tables 1 through 7. Recall that the underscored job objective numbers in the tables correspond to job objectives that are addressed by the training exercises in TC 17-12-5 (October 1974). The objective numbers that are not underscored in the tables indicate job objectives that are not addressed in TC 17-12-5.

job objectives or training objectives are mainly functions of the number of conditions and levels within conditions used in the objectives. As noted earlier, with two two-level conditions (and one task) the number of possible objectives is four. Add another two-level condition and the number is eight. Add another, and 16 different objectives can be written.

Notice also that effective training does not require a one-to-one relation between training and job objectives. Efficient programs, as a matter of fact, may have fewer training than job objectives, because the training developers will have designed exercises that cut across job objectives, and will have deliberately excluded some job objectives from training (objectives, for example, that correspond to non-critical skills and knowledge).

For the reasons noted above, comparisons between the total numbers of job and training objectives are not particularly instructive.

Other methods of comparing the job and training objectives are provided in Table 20. The first two rows of the table are iterations of data presented earlier -- numbers of job objectives and training objectives, by weapon and method of fire delivery. The numbers in the third row are new. To compute them, we took each of the 129 training objectives, one-by-one, and paired it with the job objective to which it was most related.[1] This pairing of training and job objectives provided an indication of the relevance of proposed gunnery training to the gunnery

[1]See Table 9 for information on which training objectives were related to which job objectives.

TABLE 20

COMPARISONS OF NUMBERS OF JOB OBJECTIVES AND TRAINING OBJECTIVES, BY WEAPON AND FIRE DELIVERY METHOD

	MAIN GUN				COAXIAL MACHINEGUN				CALIBER .50 MACHINEGUN	TOTALS
	Battlesight	Precision	Range Card	Range Card Lay to Direct Fire	Non-precision	Precision	Range Card	Range Card Lay to Direct Fire	Non-precision	
NUMBER OF JOB OBJECTIVES	32	28	1	13	60	40	1	30	20	225
NUMBER OF TRAINING OBJECTIVES(1)	50	35	1	1	10	10	0	0	12	129
NUMBER OF DIFFERENT JOB OBJECTIVES ADDRESSED BY TRAINING OBJECTIVES	12	12	1	1	3	6	0	0	5	40
NUMBER OF JOB OBJECTIVES NOT ADDRESSED BY TRAINING OBJECTIVES	20	16	0	12	57	34	1	30	15	195

(1) Totals do not include training objectives for Exercise 1A, Table I; Exercises 3B, 4B, and 8B, Table IV; and Exercises 7A and 9B, Table V; for reasons cited in footnotes to Table 18.

job. Nearly all of the training exercises could be related to at least one job objective. The relevance of gunnery training to the gunnery job therefore seems unquestionable.

Any job objective that had at least one training objective related to it was counted as "one," and included in the third row of Table 20.

To interpret the data in Table 20, consider the first column, labelled "Battlesight." There are 32 job objectives and 60 training objectives for main gun, battlesight firing. The 60 training objectives are related to 12 of the 32 job objectives, leaving 20 of the 32 main gun battlesight job objectives not addressed by training.

In the second column ("Precision") of Table 20, we see that there are 28 job objectives and 35 training objectives. The 35 training objectives are related to 12 of the 28 job objectives, leaving 16 main gun precision job objectives not covered by training.

Rather large numbers of job objectives not addressed by training appear in the rest of Table 20: 57 coax, non-precision objectives; 34 coax precision objectives, 30 range card lay to direct fire (coax) objectives, and 15 caliber .50 objectives.

All told, only 40 of the 225 job objectives are addressed by the training exercises proposed in TC 17-12-5 (October 1974). One-hundred-eighty-five job objectives (more than three-quarters of the total) are not addressed by training.

The most important aspect of Table 20 is that many job objectives have no training objectives related to them. This is to be expected in some measure, because the number of job objectives (225) is greater

than the number of training objectives, and because more than one training objective may be related to a single job objective. But the fact that 185 job objectives -- over three-quarters of the gunnery job as defined by our objectives -- are not addressed by training demands additional inquiry.

Tables 1 through 7, in the section of this report entitled "Job Objectives," show which job objectives are not addressed by training. A review of these tables provided information on training omissions, which are highlighted in Table 21. Here we see that many of the job objectives that are not addressed by training involve moving-moving engagements with all three weapons. Whether or not to include moving-moving engagements in training undoubtedly will be decided in light of emerging stabilization gunnery doctrine on whether or not crews should fire on the move.

Another large group of objectives that is not addressed by training is for the TC firing from the TC's station. The proposed tables include only two objectives for the TC firing the main gun from the TC's station, and both objectives are for precision engagements. The rationale for not providing more practice firing the main gun, and for providing no practice firing the coax from the TC's station may be that the TC was formerly a qualified gunner. Whether or not proficiency in firing from the gunner's seat generalizes to firing from the TC's station is questionable. Consideration should therefore be given to providing more coax and main gun practice for the TC firing from his

TABLE 21

HIGHLIGHTS OF JOB OBJECTIVES NOT ADDRESSED BY TRAINING

MAIN GUN			COAXIAL MACHINEGUN			CAL .50
Battlesight	Precision	RCDF	Non-precision	Precision	RC & RCDF	Non-precision
TC firing from TC's station Moving-moving engagements	Firing from moving tank	TC firing from TC's station Firing using telescope Firing using IR periscope Firing at moving targets	TC firing from TC's station Firing on point targets from moving firing vehicle Moving-moving engagements	TC firing from TC's station Firing on point targets from moving firing vehicle Moving-moving engagements	ALL	Firing on point targets from moving tank Moving-moving engagements Firing on aircraft

station. Consideration might also be given to having the gunner practice firing from the TC's station, because of the TC's vulnerability.

Another reason that a large number of coax job objectives is not addressed by training is because the job objectives include coax engagements using up to six different fire-control instruments, and training does not.

The 15 caliber .50 job objectives that are not addressed in training are mostly moving engagements against point targets.

Discussion

The relevance of the new exercises to the gunnery job seems unquestionable: nearly all of the exercises are related to at least one job objective.

While the relevance of the new tables is unquestionable, their comprehensiveness is not. Some job objectives receive only cursory treatment in the tables, and most are not addressed at all. The new tables address less than a quarter of the job objectives identified during this project. Whether or not the unaddressed objectives are sufficiently important or critical to be addressed in forthcoming revisions of the gunnery tables is a policy matter not within our purview.

For a variety of reasons (usually related to cost) selectivity must be exercised in deciding what to include in training. Training programs seldom can address all of the skills and knowledge required for effective job performance. Some skills and knowledge must be left out.

Making correct decisions about which skills and knowledge to exclude from training is the most difficult part of the training developer's

job. Ideally, such decisions are made on the basis of carefully controlled experiments to identify critical job requirements. In practice such studies seldom are performed, because of high costs and the obvious problems associated with empirically establishing critical requirements for effective performance in combat. Such studies are not recommended for determining gunnery training content. Instead, policy makers responsible for decisions about the content of gunnery training should review carefully those job objectives that will not be addressed in the new firing tables. Two questions need to be answered: "What are the risks associated with tank crews' failure to master the job objectives that are excluded from training?" And if the risks are great, "How can they be reduced?"

Gunnery training as proposed in TC 17-12-5 (October 1974) is not comprehensive. Questions also can be raised about its efficiency: Can more be taught (and learned) within existing constraints on training manpower, equipment, time and money? Or can existing proficiency levels be maintained at less cost? Both questions receive affirmative answers in our view.

Research should be continued to determine what effect, if any, decreased reliance on firing 105mm rounds will have on gunnery performance. All reasonable alternatives to live firing should be considered, including subcaliber and dry firing. Hopefully, the results of such studies will put to rest the debates about whether live fire is necessary or simulation is sufficient. Live fire probably will prove to be essential for some aspects of gunnery. Simulation will prove totally

sufficient for others. A significant contribution can be made by both live fire and simulation, and the problem is to find the optimal mix.

Maintaining present levels of proficiency at less cost does not seem particularly difficult. Teaching more, while staying within present budget constraints is a different matter. The job objectives developed during this project provide a data base for developing gunnery programs that teach more. Analysis is needed to specify the component skills in the job objectives. Once specified, skills can be identified that cut across job objectives. These skills can then be incorporated into enabling objectives, the mastery of which will promote learning of the maximum number of job objectives. The enabling objectives, in conjunction with terminal (job) objectives that are selected on the basis of their difficulty, criticality, or frequency of performance on the job, should be used in the design of training. Our guess is that the enabling objectives will prove to be prime candidates for simulation, and the terminal objectives for live fire.

Finally, we would be remiss if we did not comment on the need for viewing gunnery training in a larger "systems" context. Just as simulation and live fire can be viewed as means for accomplishing the goals of gunnery training, so can the goals of gunnery training be viewed as means for accomplishing other superordinate goals -- goals that involve neutralizing targets at least cost. Systems thinking demands that alternatives and supplements to training for achieving these goals be considered -- potentially less expensive alternatives and supplements such as improved equipment reliability and personnel selection techniques.

CONCLUSIONS

1. The gunnery job objectives developed during this project seem comprehensive.

If the job objectives do describe the full range of ways that crews can neutralize targets using M60A1AOS weaponry, then a basis has been provided for:

A. Comparing the content of proposed gunnery training to gunnery job content. This in turn permits comparisons between what will be included in training and what will be excluded.

B. Developing training for crews of tanks other than the M60A1AOS. The objectives for the M60A1AOS can be rewritten to form a comprehensive set of job objectives for any new tank, by replacing any conditions and levels within conditions that are unique to the M60A1AOS with conditions and levels that apply to the new tank.

C. Increasing the efficiency of gunnery training. By specifying the component skills in the gunnery job objectives, and then identifying component skills that cut across objectives, a basis will be provided for specifying enabling objectives. Mastery of the enabling objectives should promote learning of the maximum number of job objectives.

D. Evaluating the effectiveness of gunnery training. The job objectives can be used as a pool from which items may be selected for evaluating gunnery training. Objectives could be selected from the pool randomly for use in evaluation, or on the basis of criticality, difficulty, or frequency of performance. The pool could be reduced before item selection by deleting objectives that may be too costly to test.

2. The gunnery performance standards proposed in TC 17-12-5 should be revised for increased specificity and decreased reliance on expert opinion.

While some flexibility may be desirable in the setting of gunnery performance standards, the need for flexibility must be weighed against the need for "knowing where we are" with respect to gunnery

readiness. Simply making the standards less flexible will not be enough. If, as current doctrine indicates, our tank crews will be expected to win outnumbered, then the standards for performance in training must reflect the need to be faster and more accurate than prospective opponents. Our recommendation is not for research, but for review and deliberation by policy makers: Do the proposed standards reflect what is known by enemy gunnery capabilities? And what is the likelihood that meeting the proposed standards will result in gunnery proficiency that is greater than that of prospective enemies?

3. The relevance of the gunnery exercises proposed in TC 17-12-5 to the gunnery job seems unquestionable.

Nearly all of the training exercises were related to at least one job objective. The few instances where training exercises could not be related to job objectives involved minor errors in the exercises, which are being corrected.

4. Gunnery training, as proposed in TC 17-12-5, is not comprehensive.

Some job objectives are emphasized in the new tables -- objectives for main gun battlesight and precision engagements, for example. Other job objectives receive only cursory treatment in the new tables; range-card and range-card-lay-to-direct-fire objectives are examples. But most of the job objectives are not addressed at all. Examples of job objectives that are not addressed in the proposed tables include all objectives that involve the TC firing battlesight from his station, the TC firing the coax from his station, moving-moving engagements, and precision firing from a moving tank.

Policy makers responsible for decisions about the content of gunnery training should review carefully those job objectives that will not be addressed in the new firing tables. Two questions must be answered: "What are the risks associated with tank crews' failure to master the job objectives that are excluded from training?" And if the risks are great, "How can they be reduced?"

Gunnery training is one of several means for accomplishing the goal of neutralizing targets at least cost. Alternatives and supplements to training should be considered.

Just as simulation and live fire can be viewed as means for accomplishing the goals of gunnery training, so can gunnery training be viewed as a means for accomplishing superordinate goals; namely, neutralizing targets at least cost. Systems thinking demands that the full range of alternatives and supplements to training for achieving these goals be considered -- potentially less expensive alternatives and supplements such as improved equipment reliability and personnel selection techniques.

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APPENDIXES

APPENDIX A ASSUMPTIONS USED IN ESTIMATING PERFORMANCE TIMES

The assumptions which follow were made in order to provide a common frame of reference for setting performance standards. We realize full well, for example, that in combat some targets will be moving at speeds other than 8 through 15 miles per hour, that illuminating shells can be used at less than 1600 meters, and that not all targets will be immediate threats. As noted in the body of the report, one of our goals was to avoid proliferation of job objectives -- a goal that could not have been met had we presented different standards and different objectives for targets moving at 7, as opposed to 8 miles per hour; 15, as opposed to 16 degree angles of traverse; and the like. The line had to be drawn somewhere. Our assumptions define where we drew the line.

FIRING VEHICLE

General

1. During battlesight engagements, the appropriate range and ammunition are indexed into the rangefinder and computer, respectively, 1100 meters for HEAT, and 1600 meters for SABOT, and the round is loaded in the chamber.

2. During precision engagements with the tank commander firing, the tank commander is observing through his optics when starting the fire command.

3. Range card data are available for firing the main gun or coaxial machinegun.

4. In firing range card lay to direct fire, the range card data are used to lay the main gun or coaxial machinegun in the general vicinity of the target before illumination is used to bring fire to bear on the target.

5. When firing the main gun using range card lay to direct fire, ranging is required, regardless of range, once the target is illuminated with white light or illuminating shells.

6. When firing the coaxial machinegun using range card lay to direct fire, ranging is required beyond 600 meters once the target is illuminated with white light or illuminating shells.

7. When the tank commander or gunner has fired the main gun, he is able to sense the first round and apply burst-on-target (BOT), if required. For the purposes of this study sensing of "lost" and subsequent fire commands were not considered.

8. Starting or opening times for all engagements begin when the tank commander issues the alert element of the fire command.

9. The tank commander cannot range on targets using the metascope attached to the range finder. The metascope can be used effectively against targets emitting and IR light source, but it is not practical.

10. The tank commander does not use the precision method when firing the caliber .50 machinegun. He will apply the burst-on-target (BOT) technique of fire against most targets.

11. During engagements where the tank commander must fire the main gun, it probably is impossible to range and track the target at the same time. (Ranging and tracking are both right-hand operations on the M60A1AOS tank.) The tank commander can fire using battlesight or by indexing an estimated range to target into the rangefinder.

Motion

12. The speed of the firing vehicle when engaging targets on the move is 10-15 MPH. This speed was selected as an optimum for firing on the move, based on information in FM 17-12.

13. When firing on the move at a moving target, the firing vehicle and target are moving in opposite (lateral) directions.

14. When firing on the move at a stationary target, the tank is moving toward the target at an angle of 15 degrees or less.

Fire-Control Instruments

15. The IR periscope is considered the primary fire-control instrument when firing at night at 1100 meters or less. Beyond 1100 meters, white light and day sights are considered the primary fire-control instruments.

16. When using the gunner's telescope, the maximum effective range for SABOT is 2800 meters; and 3200 meters for HEAT, HEP, and BEEHIVE.

17. The gunner's day periscope is the primary firing sight for engaging point targets with the coaxial machinegun during the day, or at night using white light.

18. The infinity sight is the gunner's primary firing sight for engaging area targets with the coaxial machinegun during the day, or at night using white light.

19. The IR periscope is the gunner's primary firing sight for engaging area targets with the coaxial machinegun at night using IR.

Visibility

20. The maximum effective range of IR is 1100 meters.

21. The maximum effective range of white light is 1600 meters.

22. Illuminating shells are required to enhance target visibility beyond 1600 meters. Illuminating shells can be used at all ranges under 1600 meters. But for purposes of this study, we assumed that IR and white light would be used within their range capabilities; and illuminating shells would have to be used at farther ranges, if white light were required.

23. Using white searchlight or illuminating shells does not affect gunnery performance differentially.

TARGET

General

24. The target always is considered an immediate threat to the tank crew. The target must be engaged with the weapon system, method of fire delivery, fire-control instrument, and ammunition that will neutralize the target in the least amount of time. All targets were considered threats in order to derive the minimum performance standard for target destruction.

25. Troops are considered to be stationary area targets.

26. The target locations for all engagements with the main gun, coaxial machinegun, and caliber .50 machinegun are within a 30 degree arc to the front of the tank.

Motion

27. The speed of moving targets is 8-15 MPH.

APPENDIX B Constants Used in Estimating Performance Times

CONSTANTS FOR OPENING (FIRST-ROUND) TIME

ACTIVITY	TIME (sec)
. Firing the main gun, battlesight, from a stationary tank target from the gunner's position	7
. Firing the coaxial machinegun at a stationary tank against a stationary target from the gunner's position	8
. Firing the caliber .50 machinegun from a stationary tank against a stationary target from the commander's position	7
. Firing the main gun or coaxial machinegun in the stabilized mode from a moving tank against a stationary target	3
. Firing the caliber .50 machinegun in the non-stabilized mode from a moving tank against a moving target	5
. Firing 60, 7.62mm rounds, using 20-25 round bursts	10
. Firing 100-150, 7.62mm rounds, using 20-25 round bursts	25
. Firing 50, caliber .50 rounds, using 10-20 round bursts	9
. Firing 100-150, caliber .50 rounds, using 10-20 round bursts	23
. Firing 50, caliber .50 rounds at aircraft targets	4
. Moving down from tank commander's open hatch position to use rangefinder	3
. Indexing HEP for coaxial machinegun	1
. Indexing firing data using the auxiliary fire control instruments	1
. Using the gunner's telescope	2
. Using aim-off with the rangefinder or gunner's periscope when firing BEEHIVE ammunition	2
. Using infrared (IR) illumination	10
. Using white light (searchlight or illuminating shells)	5

ACTIVITY	TIME (sec)
. Tracking from a stationary or moving tank	3
. Ranging on a target	3
. Setting the fuze on BEEHIVE ammunition	5
. Loading, after setting fuze on BEEHIVE ammunition	3
. Pausing before firing the main gun	1

CONSTANTS FOR (SECOND-ROUND) TIME

ACTIVITY	TIME (sec)
. Using infrared (IR) illumination	2
. Using white light (searchlight or illuminating shells)	2
. Sensing	4
. Loading, after setting fuze on BEEHIVE ammunition	3

AMMUNITION FLIGHT TIME	TIME (sec)
. SABOT/HEAT	
1100 meters	1
1600 meters	2
3200 meters	4
. BEEHIVE	
1100 meters	1
1600 meters	2
3200 meters	5
. HEP	
1100 meters	2
1600 meters	3
3200 meters	8

END